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ARTICLES

AERIAL SPRAY OPERATIONS IN MERCED COUNTY, CALIFORNIA

EDGAR A. SMITH [1]

THE MOSQUITO PROBLEM IN MERCED COUNTY IN RELATION TO THE NEED FOR AERIAL SPRAYING—The Merced County Mosquito Abatement District includes nearly two thousand square miles of land. Approximately three fourths of this area presents a mosquito control problem. Although nineteen different kinds of mosquitoes are to be found in the district, most of the complaints about mosquitoes may be traced to only two species, namely *Aedes dorsalis* and *Aedes nigromaculis*. This is due not only to their extreme abundance, but also to their habits, for they are the most vicious biting mosquitoes in the valley, have the longest flight range and bite day or night. Because of their preferred habitat, probably 90 per cent of the necessary aerial spraying in the district is for control of these two mosquitoes. Both species have adapted themselves perfectly to the irrigation system of the San Joaquin Valley. Virtually every irrigated crop in the valley produces its share of *Aedes* mosquitoes on every irrigation from April to October. By far the greatest producer of all is permanent pastureland which is seeded with pasture grasses and irrigated regularly every 7 to 21 days all season. Unimproved land which is flooded and used as pasture also contributes a large share of the county's *Aedes* population. Ladino clover, alfalfa, barley, cotton, corn, beans etc. all produce *Aedes* mosquitoes in varying degrees.

According to the 1946 Agriculture Report, Merced County has 850,000 acres of pasture, a large part of it flooded 1–4 times a year, 37,600 acres of permanent pasture flooded every 7–10 days, 85,500 acres of alfalfa, and 73,000 acres of barley. Obviously even if only a small part of this land was producing mosquitoes at any one time it would present a problem of such magnitude that it could be handled only by aerial spraying. Actually, so much of this land is continually producing mosquitoes that it would be financially impossible to operate enough spray planes to keep the mosquitoes under control over the entire area throughout the season. However, it is possible to reduce substantially the mosquito population in the more populated areas for the greater part of the season by carefully selecting the areas to be sprayed and keeping abreast of current developments with a thorough system of inspection.

AIRPLANES AND EQUIPMENT USED BY THE MERCED COUNTY MOSQUITO ABATEMENT DISTRICT FOR AERIAL SPRAYING—The District has used two airplanes in its spray program, an Aeronca Champion owned by the District and a Stearman biplane under contract.

The Stearman spray plane was developed in the late summer of 1946 by the Inland Aviation Company of Los Banos, California. It is a PT-17 with a Pratt & Whitney 450 H.P. engine and was modified for liquid spray work by Lloyd Stearman, the designer of the original Stearman airplanes. The modified plane is known as an Inland Boeing 75-A. It is equipped with a 130 gallon tank, a spray boom and an exhaust aerosol apparatus.

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The spray boom is actually four separate booms equipped with a nozzle on each end. Each boom may be operated separately or in combination with one or more of the other three. This makes it possible to vary the output from 7 to 28 gallons per minute. In actual practice on mosquito work this makes possible dosages of from one-half gallon to ten gallons of liquid per acre.

The exhaust aerosol apparatus was constructed in accordance with the recommendations of the U.S.P.H.S. and T.V.A. in Public Health Report Volume 61, Number 32, August 9, 1946. It is capable of putting out from 1 to 14 gallons per minute or from 1 pint to 1 gallon per acre. The changeover from spray boom to exhaust aerosol can be made in the air or both can be operated together.

The Aeronca Champion was equipped with a metal propeller and the 65 H.P. engine was altered to increase the horse power to 75. The spray apparatus was designed by Lloyd Stearman and built by Inland Aviation Company. It consists of a spray boom with 10 nozzles, Spray system "whirljet" spray nozzle 1/8B5 and a 35 gallon tank. Liquid is supplied under pressure to the nozzles by an Oberdorfer pump No. 4, Type A, Form Y, 10 gallon per minute output. The pump is driven by a four blade aluminum alloy adjustable pitch propeller. Tank, boom, and all piping is aluminum alloy. Output is varied from one-half to one gallon per acre by means of a pressure regulating-valve.

RATES AND METHODS OF AERIAL APPLICATION OF INSECTICIDES FOR MOSQUITO CONTROL IN MERCED COUNTY. The only insecticide used for aerial spraying has been DDT in its several different forms. Most of the work has been done with technical grade DDT in diesel oil, and xylene as an auxiliary solvent. In some cases the 25 per cent emulsible has been mixed with diesel oil and in a few cases the 25 per cent emulsible has been mixed with water. Five, ten and fifteen per cent solutions have been used, but in all cases the application rate of actual DDT was approximately the same. The first season a five per cent solution of DDT was used in the Stearman plane with the spray boom. It was applied at the rate of one gallon to the acre giving approximately .4 lb. to the acre. The second season a 10 per cent solution was applied at the rate of ½ gallon to the acre giving the same dosage of DDT. A fifteen per cent solution was used in the exhaust aerosol and applied at the rate of one quart to the acre giving approximately .3 lb. to the acre of actual DDT.

FIG. 1. The Inland Boeing 75-A showing the aerosol apparatus. The aerosol stack is fabricated from sheet stainless steel.

FIG. 2. Spraying an urban area. The entire city of Los Banos, California was sprayed to combat a serious infestation of *Aedes nigromaculis*. This treatment was only partly successful, but was given widespread credit by the local citizens for completely wiping out the mosquitoes for the remainder of the season as well as preventing the usual fall hordes of houseflies.

FIG. 3. During the 1946 season a total of 8,000 acres were sprayed by plane in the following areas: Merced, Planada, Le Grand, Los Banos, Gustine, Stevinsin and Hilmar, California. Nearly all of this spraying was of permanent pasture. Several drainage ditches and stream channels were sprayed as well as some forested river bottom lands and one urban area.

FIG. 4. Spraying pasture land. Most of the aerial spraying in the 1946 season was done in pasture situations such as this. This type of aerial spraying was 100 per cent effective against larvae with a residual effect through three irrigations and was 95 per cent effective against adult mosquitoes.

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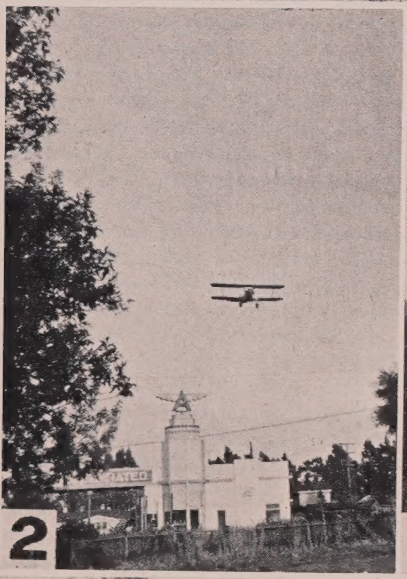
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The flight pattern used by all of the pilots is the same as was used by commercial dusting and spraying planes whenever possible. The plane was flown cross wind starting at the downwind edge of the field. Turns at the end of the flight line were made downwind so as to avoid going through the spray. When the wind velocity got up to 10 or 15 miles per hour, it was sometimes possible to continue spraying by flying into the wind. No spraying was done at a wind velocity of greater than 15 miles per hour. The Stearman plane flew at about an elevation of fifteen feet to give a swath width of about sixty feet with the spray boom and about 75 feet with the aerosol. The Aeronca flew at about an elevation of 12 feet to give a swath width of about 35 feet.

The use of the aerosol was extremely dependent on the weather, and was restricted to the early morning hours. It was possible to use the aerosol from daybreak until the beginning of the thermal upcurrents which during the summer months usually meant from daybreak at about five A.M. until eight A.M. or only two to three hours a day.

The spray boom was more versatile and could be used until a strong wind came up or until it became quite warm. This meant about five or six hours of flying a day as it was usually possible to work until nearly noon with either plane. It was also possible to use the spray boom for an additional two to three hours in the evening and this was done regularly with the Aeronca. On one occasion the Stearman plane continued spraying from 6:00 A.M. until 4:00 in the afternoon, but such perfect weather conditions were rare.

Ordinarily spraying is continued until it becomes so warm that the spray no longer reaches the ground or until the wind becomes so strong or gusty that it is impossible to obtain an even distribution of the spray particles. That decision was normally left up to the man on the ground. The spray operations ordinarily required two men on the ground. One drove the truck with the spray material and operated the pump for loading the plane; the other man, usually the Division Foreman or Inspector, worked with the plane. In some cases it was necessary to measure off the swath width and signal the plane for each flight line. This was true in rice fields, duck clubs, etc. or any other large areas where there were no roads, fences or other markers for lining up the flight lines. Signaling was accomplished in the smaller fields simply by pacing off each swath and standing or waving a white flag at the end of the field. Where it was possible, a jeep or truck was driven ahead and parked for each swath. For long flight lines of one to two miles, it proved quite satisfactory for the jeep to shoot out a puff of the aerosol smoke as the plane approached each flight line. The smoke could be seen several miles away. Even when it was not necessary to signal the plane for swath width, the ground man stayed right with the plane in order to insure that an effective job was being done and to obtain a record of the area covered.

THE PLACE OF AERIAL SPRAYING IN THE OVERALL PROGRAM OF MOSQUITO CONTROL. Aerial spraying is only used when it has a definite advantage over ground spraying. Some areas are inaccessible from the ground, but may be reached easily from the air. In some situations where time is a factor, the mosquitoes might hatch out before they could be treated from the ground, but could be taken care of from the air. Spraying of large areas can be done more cheaply from the air than from the ground. With the Stearman plane it is not economical to spray individual fields smaller than 100 acres as so much time is lost in the turns that it raises the cost to more than it would be for ground treatment. With the Aeronca, it is not economical to spray fields smaller than 10 acres. With either plane, spraying of large areas brings the unit cost down to

a point where it is equal to or less than the cost of ground spraying.

Most of the aerial spraying in Merced County has been in the large areas of pasture land for control of both larvae and adults of *Aedes* mosquitoes, principally *dorsalis* and *nigromaculis*. No attempt was made to spray only that part of a pasture under water. When a pasture was partially flooded and developing mosquitoes, the entire field was sprayed. In a single large field or a series of smaller adjoining fields, a single spray job would be an adulticiding treatment at the end first flooded, a larviciding treatment of the actual water area, and a prehatching treatment of the end not yet flooded. Hence, it was necessary to arrive at a dosage which would effectively accomplish all three purposes. After much experimentation, a dosage of .4 lb. per acre was decided upon. This dosage gave 100 per cent larval kill, was a good prehatching treatment and gave a 95 per cent plus kill of the adults. In individual cases, this treatment has been effective through as many as three or four irrigations or a period of three to six weeks.

In addition to the spraying of the pasture land, the airplane has been used to advantage in otherwise inaccessible places such as: tule ponds, clogged drain ditches, sloughs, riverbottoms and gold dredger-pits. Entire cities have been sprayed as well as certain urban areas for fairs, celebrations, etc. Extensive rice fields which could be controlled in no other way were treated by aerial spraying.

Some of the pastures and duck clubs which remained flooded for long periods of time were sprayed for control of *Culex tarsalis* larvae. Sewer farms were sprayed for *Culex quinquefasciatus* and *Culex pipiens*. Ditches and sloughs were sprayed for *Anopheles freeborni, Culex stigmatosoma* and *Culex tarsalis*. The rice fields were sprayed for *Anopheles freeborni* and *Culex tarsalis*. The gold dredger-pit area along the Merced River produces all 19 kinds of mosquitoes found in the County, so was sprayed in an attempt to kill larvae and adults of as many kinds as possible. In some cases, the spray boom and aerosol were used together in order to get penetration through the trees and to get a high initial kill and a lasting effect.

The Relation of the Mosquito Aerial Spray Program to the Wildlife of Merced County. Although no serious problem has yet arisen, there is always the possibility of deleterious effects of DDT on fish, birds and beneficial insects.

The dosage used, .4 lb. per acre, is sufficient to kill small fish in confined water areas such as shallow puddles left after flooding a field or ditches in which the water has been turned off. However, in these situations the fish would probably die anyway. It is doubtful that this dosage would be enough to kill any fish in the deep flowing canals, ditches, sloughs and rivers. Since most of the spraying is done on pasture and swamp land, the danger to fish does not present a very serious problem. A note of caution might be added in regard to the spraying of lakes, reservoirs or even slowly moving rivers. In one case in the upper Merced River area a number of bass were killed. The local fishermen blamed it on the mosquito spraying. Although the dosage applied would hardly be sufficient to kill such fish, in slowly moving water it is quite possible in this area that the pilot became confused and repeated the same swath several times. Such a heavy dosage would certainly be enough to kill fairly large fish.

There have been no ill effects on the bird population so far as is known. However, with nearly 300 duck clubs covering over 70 square miles, the possibility makes it essential that every precaution be taken. It seems very unlikely that there would be any direct effects of the DDT on the ducks, but since many of them eat a certain number of aquatic insects which are readily killed by DDT, it is possible that the ducks might be affected. The only place where this has come up is on the California State Game Refuge at

Los Banos, California. The manager of the game refuge was hesitant about allowing the district to spray his ponds. Instead of larviciding the ponds, the district waited until the mosquitoes had hatched and then adulticided the area with the exhaust aerosol.

Several thousand acres of duck clubs have been aerial sprayed with the same dosage used on pastures and swamps without a single complaint from the owners or the hunters.

The problem of killing beneficial insects has come up several times in regard to bees. Several complaints have come in to the effect that the aerial spraying was killing off bees in certain hives. Every case so far has eventually been traced to other spray materials, principally arsenicals. Although the pilots take every precaution to avoid spraying directly on bee hives, in one or two cases it has been done. In one case a truckload of beehives was in a back yard in town and was covered with the DDT spray. The owner observed the hives closely and reported no ill effects whatsoever.

There is also the possibility of materially reducing the populations of pollinating insects and insects in general. As yet so little research work has been done on such problems that it is difficult to determine how important the problem actually is. During the normal spray program, the only other insect which was obviously consistently killed off was the housefly. This was definitely an advantage as it resulted in much good will towards the district.

Just what the results of repeated sprayings in the same field will be is hard to predict. However, one incident involving the application of a higher dosage than normal showed some interesting results.

In one particular field, 100 acres of permanent pasture, a dosage of .8 lb. to the acre was applied by mistake through faulty adjustment of the pressure relief valve. In this field no mosquito larvae were found for nearly sixty days. However, at the time of the spraying many other insects in the area were also killed. Within ten or fifteen minutes the surface of the water was blackened with the bodies of insects such as bugs (notonectids and corixids), beetles (hydrophilids and dytiscids, etc.), dragonflies, mayflies, bees, wasps, etc. It almost seemed to be raining insects for a few minutes.

The danger of seriously upsetting the balance of nature is one which should be considered with due caution by those responsible for large scale aerial DDT spray programs.

COMPARATIVE TABLES — I.

Aerial Spraying	*Ground Spraying*
Cost: Comparable to or cheaper than ground spraying where large areas are sprayed.	*Cost:* Cheaper than aerial spraying for small areas.
Time: Much faster. Possible to spray from 100 to 400 acres per hour.	*Time:* One truck with a spray boom can spray from 5 to 20 acres an hour.
Accessibility: Plane can spray many places which are inaccessible from the ground such as large swamps, tule ponds, duck ponds, rice fields etc.	*Accessibility:* Ground rig can sometimes get to spots with overhead obstructions which would prevent plane operation.

COMPARATIVE TABLES — II.

Small Plane (Aeronca Champion)	*Large Plane* (Inland Boeing 75A)
1. Can spray an average of 125 acres an hour.	1. Can spray an average of 270 acres an hour.
2. Economical for spraying areas of 10 acres or larger.	2. Economical for spraying areas of 100 acres or larger.
3. Can spray ½ gallon to 1 gallon per acre.	3. Can spray from 1 pt. to 10 gallon per acre.
4. No aerosol.	4. Equipped with exhaust aerosol apparatus.

COMPARATIVE TABLES — III.

District Owned Plane		*Rented Plane*	
Direct costs of operating the Aeronca Champion airplane from April 15, 1947 to Sept. 30, 1947. Not including the cost of insecticide.		Rental of 450 H.P. Inland Boeing 75A biplane. May and June, 1947.	
Gasoline and oil	$ 697.81		
Repairs & overhaul	649.63		
Hangar rental	180.00		
Fire & Theft Ins.	126.00		
Liability Ins.	180.00		
Compensation Ins.	371.68		
Pilot Salary	2,479.50	Plane rental	$2,939.83
Total direct cost for 1947 season	$4,684.62	Total	$2,939.83
Total acres sprayed	71,290		14,692
Cost per acre	$ 0.07		$ 0.20
Total Hours of flying	564		54
Cost per hour	$8.30		$55.00
Total gals. of spray	32,996		7,646
Cost per gal. sprayed	$ 0.14		$ 0.38
Gals per hour	58		141
Acres per hour	126		272

The above costs do not include the cost of 10 per cent DDT larvicide in diesel oil at 50¢ per gallon or the capital cost of the Aeronca aeroplane and the spray equipment.

COMPARATIVE TABLES — IV.

District Owned Plane	*Rented Plane*
1. Capital Investment Aeronca plane $2,777 65 Spray equip. 881.50 $3,659.15	1. Capital Investment None
2. Unit Operating Cost (does not include capitalized cost of airplane and equipment) $8.30 per hour $0.07 per acre covered $0.14 per gallon sprayed	2. Unit Operating Cost $55.00 per hour $ 0.20 per acre covered $ 0.38 per gallon sprayed
3. Convenience—always ready for immediate operation on short notice.	3. Require 24 hour notice and even then not always available.
4. No problem.	4. Minimum guarantee of 1 hour's flying time if called out.
5. Pilot is district employee, trained in mosquito control methods and is familiar with the terrain.	5. Same pilot is not always assigned to the job, hence is not familiar with the work or the terrain.

COMPARATIVE TABLES — V.

Aerial Spray — Boom	*Aerial Aeorosol*
1. Large droplet size. Mass median diameter of 150 microns	1. Small droplet size. Mass median diameter of 50–75 microns.
2. Fair penetration through foliage.	2. Excellent penetration through trees, bushes and tall grass.
3. Maximum kill in 24 hours.	3. Maximum kill in 3–6 hours.
4. One load of 130 gallons dispensed in 20 minutes at ½ gallon to the acre. 260 acres to the load. 10 per cent solution of DDT used to give .4 lb. per acre.	4. One load of 130 gallons dispensed in one hour at 1⅓ qt. to the acre. 390 acres to the load. 15 per cent solution of DDT used to give .4 lb. per acre.

CLASSIFICATION OF AREAS SPRAYED

	Acres	*Hours*
Pasture and Swamp	82,586	605:32
Ditches, Canals and Sloughs	1,986	5:25
Ponds	300	1:10
Rice Fields	320	2:19
Urban	210	1:03
Sewer Farms	580	2:31
Total	85,982	618:00

DATA ON AERIAL AEROSOL APPLICATIONS*

Plane rental	$1,743.64
Total acres fogged	9,222
Cost per acre	.17
Total gallons of aerosol	2,383
Cost per gallon aerosol	.73
Gallons per hour	74
Acres per hour	288

* The aerosol application was restricted largely to rice fields, heavily wooded river-bottom land and the gold dredger-pit area.

ADULT MOSQUITO CONTROL A USEFUL EMERGENCY TOOL

ROBERT L. VANNOTE, Secretary
Passaic Valley Mosquito Control Conference, Morris Plains, New Jersey

Mosquito control as commonly practiced, is carried on with public funds largely on private properties. Until recently, such work has been directed principally toward treatment of mosquito breeding water to reduce the opportunities for multiplication of these insects. Much of such mosquito breeding water, and consequently the bulk of such work, is concentrated on lands of little or no economic value.

The older methods of control have included a program of surveys and planning, leading to the considered use, each in its proper place, of both permanent and temporary control measures.

Permanent control may include filling or draining, or other measures to assure the permanent elimination of mosquito breeding water; it may consist of carefully engineered systems of ditching, as of a tidal salt-marsh, to provide for alternate flushing by, and prompt withdrawal of the tidal water; or it may employ dikes and tide gates or pumps to exclude tidal water while providing for the escape or removal of rain water.

Temporary control may include spraying, dusting, or otherwise treating mosquito breeding water with oil, or with other mosquito larvicide materials, with the addition more recently of space treatment with pyrethrum, DDT, or other mosquito "adulticides," applied as sprays or as aerosol fogs, and of residual applications of such insecticides to vegetation and other mosquito resting places for the destruction of adult mosquitoes after emergence. Temporary control includes, also, inspection, correction of yard nuisances such as neglected rain barrels, clogged eave troughs, and other temporary accumulations of water, as well as public education to enlist popular cooperation and support.

Temporary control is a very important part of mosquito control work, and must be given a prominent place in any mosquito control program. When a community is plagued by mosquitoes or by mosquito borne disease, unless noticeable relief can be given promptly, or at least a convincing demonstration area established, public patience and public support from those who pay the bill will be short lived.

Many things can upset the most skillfully planned and executed mosquito control program. Only those mosquito control programs which are financed by Federal funds for critical health reasons can hope to receive financial support sufficient to control mosquitoes under all conditions. Elsewhere it must be a compromise between how much the community can, or is willing to pay for relief, and how much mosquito annoyance it will tolerate.

Permanent control, where practicable, will usually involve a greater initial cost; but, even with provision for subsequent maintenance, is usually less expensive in the long run. Temporary control, having to be repeated over and over again, is usually more expensive in the long run; but gives prompt results at less initial cost.

For these reasons the available funds are best divided with a considered balance between permanent and temporary control, planned to provide as much permanent control as is compatible with a satisfying degree of immediate overall temporary control and an adequate reserve to meet peak-load emergencies.

Provision for meeting peak load emer-

gencies is important, because any mosquito control program is vulnerable to abnormal weather conditions, adverse tides or winds, or periods of excessive rainfall that produce an exceptional abundance of mosquito breeding water and peak emergence.

Such conditions may result in a temporary loss of control for days or weeks, depending on species of mosquito and breeding potential, with a corresponding loss of public confidence.

Prior to 1935 no means was available to the mosquito control worker by which he could cope successfully with a brood of adult mosquitoes after emergence. It was then accepted by the mosquito control worker and his public alike, that mosquito control as limited by economic considerations was practicable in periods of normal rainfall, but must be expected to break down during the one or two periods of excessive rainfall usually expected in midsummer.

The development of pyrethrum larvicides in 1931 and the four years following, introduced a new and effective weapon, which provided effective means of combatting adult mosquitoes regardless of abundance; and methods for its use were developed to protect outdoor assemblies from annoyance by these insects.

By mixing one part of the pyrethrum larvicide stock emulsion with nine parts of water and applying it with a power or hand sprayer at the rate of 30 to 50 gallons per acre, adult mosquitoes are killed, and further flights repelled. Under average conditions of annoyance (20 to 50 *vexans* per night per trap) such an application made in the early afternoon provides good protection until the following morning. Under more severe conditions a second application around the margins of the treated area may be required.

This was a great stride forward and although it was impossible to treat whole communities by this method, public functions such as games, carnivals, fairs or block parties could be handled as a public convenience. Individuals could purchase the materials and thus protect their own yards.

Public reaction to this type of control was immediate. While spraying, comments could be heard to the effect that "the Mosquito Commission is really on the job." When such work was necessary, the before and after conditions were so marked that no one could doubt the effectiveness of the work. The committees responsible for outdoor public gatherings soon competed with one another to secure the service and often advertised "Area under control by the County Mosquito Commission."

In most counties using this method, control policies had to be adopted to rule on the applications for treatment. To strictly public functions with no profit motive, such as public celebrations, church or Boy Scout outings, etc., the services were free. Semi-public functions such as benefit carnivals were required to pay costs of materials and labor. Private functions were urged to make private arrangements for the service. To my knowledge the largest area receiving this type of treatment was the Morris County Grange Fair involving some 40 acres with the protection of some 30,000 persons.

The development of DDT as an insecticide for mosquito control by the U. S. Department of Agriculture at the Orlando station opened a new door to adult mosquito control.

It is now practicable to spray large areas by airplane for the control of adult mosquitoes after brood emergences, with amazing results. The experience of Suffolk County on Long Island, N. Y., has demonstrated that emerging broods of adult salt-marsh mosquitoes can be effectually destroyed by the aerial application of 2 quarts of 1 per cent DDT in fuel oil per acre. Under the direction of Mr. C. T. Williamson over 20,000 acres of open salt-marsh are under regular spray control, utilizing this method to reinforce the normal salt-marsh ditching. Adverse tides or winds no longer create a situation where mosquito control need break down.

The adult mosquitoes may even be killed before they reach the upland and spread out.

Our experience in the Passaic River Valley in New Jersey is interesting to relate, as the flood water breeding potential totals some 20,000 acres. During periods of brood emergence, traps in nearby towns catch as high as 2,000 *Aedes vexans* and *trivittatus* per night. In the mosquito flight range of the Valley we have one and a quarter million residents, and assessed property valuations computed at 100 millions. The mosquito broods move in a vast front spreading out from the flood areas at the rate of about 1½ miles per day. The movement can best be described as a "percolation" through the grasses and low shrubs.

For two successive years we have been able to halt the movement and reduce annoyance to a reasonable point by the application of 3 per cent DDT in Shell horticultural oil base at the rate of 3 quarts per acre. The terrain involved was open fields, low dense woods and shaded residential areas, in each case approximately 800 acres. The cost was approximately 75 cents per acre. The rate of application and the high concentration of DDT were necessitated by the screening canopy of vegetation. As we were covering a residential area the special oil base was used to prevent spotting of vegetation, house paint and clothes drying in yards.

The aerosol fog units such as the Todd (Fig. 1), Bessler (Fig. 3), trucks equipped with venturi exhaust type generators, and the Hession (Fig. 2), offer another approach to the problem.

During the early summer of 1946 a Todd Fog Unit was purchased for experimental use. A 5 per cent solution of DDT in fuel oil was used as a standard fog insecticide. One of our tests involved 4 square blocks of residential area in the borough of Chatham. The area was fogged at night under good conditions. For the following 3 days, mosquitoes in the test area were not annoying; although on the 3rd day they had again drifted in.

The results were so startling that the residents of the borough exerted sufficient pressure to compel the borough officials to purchase a machine. By agreement, the Mosquito Commission operated the machine at cost on an experimental basis.

Chatham, with a population of 5,500 covers an area of some 5 square miles, having 26 miles of streets laid out in a rectangular pattern, with the shortest distance between the streets approximately 300 feet. During the month of August the entire borough was fogged 5 times with the equipment in operation for 18 days of approximately 5¾ hours of operation per day. A total of 433 gallons of 5 per cent DDT in fuel oil were used.

Observations indicated that the fog unit was of little value when a brood was in motion, as no residual effect develops from the dry fog. However, when the strength of the migration was cut down by aerial spraying of the surrounding area, the fog unit cleared out the mosquitoes already present, and gave excellent protection in the areas covered.

The fog unit was used at the Morris County Grange Fair in August of 1946 with excellent results. Compared to previous experiences with pyrethrum larvicides, a reduction in labor was effected from 81 hours to 41 hours and a reduction in materials from 2,640 spray gallons of pyrethrum larvicide to 78 gallons of 5 per cent DDT in fuel oil.

In 1947, tests were continued with the Todd Insecticidal Fog Applicator, and a Hession Microsol Field Unit was also purchased and put into use. It was observed at once that the two machines did not conflict in their operations. The Todd unit produced a dry fog that was particularly suitable for residential type work leaving practically no residual effect; however, its use was greatly limited by wind and atmospheric conditions. The Hession machine produced aerosol particles of much larger size; moreover, the volume was so great that a definite resid-

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ual deposit could be demonstrated as far as 200 feet from the machine. The coarser Hession mist is much less influenced by atmospheric conditions and provides the nearest approach to airplane treatment with ground equipment.

For outdoor assemblies the Hession residual deposit is a distinct advantage and there the danger of damage to paint or vegetation is of little consequence. The Todd was reserved for residential areas where its dry fog is preferable because safer for ornamental plants.

Tests outlined for 1948 include the wide testing of the Hession and the Beskill (similar to Todd) units for residential as well as for area control, and for control of both adults and larvae. The Hession unit offers unique advantages for larval control in large open areas, since the output can be regulated to exceed 180 gallons per hour, the type of mist produced tends to hug the ground, and the 120 mile per hour initial velocity gets it well started in the proper direction.

The successful tests already made of adult mosquito control with aircraft and ground equipment, clearly justify a further appraisal of this new tool and its possibilities.

At the present time and under our conditions, adult mosquito control must be considered an emergency measure, and not to be adopted as the principal means of mosquito elimination. The standard procedures of temporary and permanent control cannot yet be replaced due to such reasons as:

1. The high cost of adult control.
2. The complicated factors involved.
3. The inability to operate such equipment for long periods due to weather conditions.
4. The possible damage to vegetation or useful insect and wildlife due to continuous applications of DDT.

As an emergency measure adult mosquito control serves several important functions: It makes it possible to cut down the peak abundance of a brood that would otherwise spoil a season's record for effectual control; it can provide a quick clean-up of disease-bearing mosquitoes in residential areas; and, it can provide temporary relief at community functions located beyond the zone of normal control.

The operation of equipment for adult mosquito control is a job for experts, particularly where such operations are conducted in populated areas. Only those with a broad background of mosquito control work are equipped to evaluate all the complicated community problems that can arise from such a procedure. I refer to such matters as advance publicity, police protection with respect to traffic problems and the wild antics of children, technical operating procedures, and the necessary follow-up checks.

Public reaction should be understood in order to avoid accidents due to fright or confusion; and here the proper kind of publicity may avoid many complications. Permissive laws should be carefully examined to determine authority to operate over private residential lands, and insurance coverage should be checked. If mosquito annoyance is severe, public response and demand will be so immediate and pressing that the control agency may be hard pressed to meet the demand.

In conclusion, I wish to point out that we have a new tool in our mosquito control kit. It answers emergency conditions when normal control is out of balance. It brings control work out of the breeding place and directly in public sight. Expert planning and operation are required to control its operation, especially until such time as continued research can establish wholly safe and fool-proof procedures.

Fig. 1—TIFA, Todd Insecticidal Fog Applicator.
Fig. 2—Hession MICROSOL.
Fig. 3—The Besler BES-KIL.

OBSERVATIONS ON A TIFA USED BY THE CONSOLIDATED MOSQUITO ABATEMENT DISTRICT

W. H. DICKINSON, DONALD MERRITT AND JAMES HOUGH[1]

The insecticidal fog applicator manufactured by the Todd Shipyards Corporation, known as the TIFA model 40-E-46, was used to excellent advantage by the Consolidated Mosquito Abatement District during the peak of the 1947 mosquito producing season.

Before purchasing a TIFA, its possible use as an adjunct to our standard and specialized equipment was carefully considered. With 21 jeeps, 2 cars, 2 pickups, and a truck, of which each of the jeeps and trucks was fitted with an exhaust type of thermal aerosol generator similar to the "plumber's nightmare" (Raley, 1947) first attached to the exhaust pipe of a 4-wheel drive Dodge truck, it was decided to add this new type unit for more extensive fogging work. In an attempt to achieve a one-man unit, our jeeps also carry an Essick spray rig, a spray boom, and a hand spray outfit. The District also has an airplane which is fitted with an exhaust aerosol generator, as well as a spray boom.

With the experience of 21 one-man units, supplemented by the remainder of our equipment, it was decided that a volume production of adulticiding fog was needed for those areas too extensive to be covered economically by the jeep units. After evaluating the various types available, a TIFA was added to the District's equipment. This was assigned to one man and could be called upon wherever needed. It was of special value in areas where undiscovered larval sources produced flights of adult mosquitoes which would then move into heavily inhabited areas where individual fogging of buildings was impossible. It has also been used to great advantage in areas infested with flights of mosquitoes from outside the control area of the District. Previous work with the 21 one-man units enables us to compare results of the TIFA with past results obtained from our smaller units.

Use of the TIFA for larviciding has been limited; therefore we do not feel in a position to discuss the TIFA's application to larvicidal phases of mosquito control operations at this time.

However, we feel that the machine has admirably fulfilled a need for volume production of an adulticiding fog. The TIFA has been used in many situations, and has performed satisfactorily in all. It was phenomenal, to be in a field producing large numbers of *Aedes,* when the TIFA was turned on, and the clouds of fog would roll by; then, after the passing of the cloud, it would be noticed that the mosquitoes had stopped biting; and then there would be none!

The ease with which the TIFA can be installed on a jeep makes this an ideal piece of equipment for field work. We have many irrigated pastures here, and the larger vehicles will bog down in these areas, so we are forced of necessity, to rely on a light truck. The larger the spraying rig, and the heavier it is, the more restricted are its uses in the field. This, then, is a great advantage which the TIFA has; it is light enough to mount on a jeep, and still effective enough to cover large areas with fog, where even the jeep can not go.

[1] Entomologist, Superintendent, and Field Operator, respectively, of the Consolidated Mosquito Abatement District, Fresno County, California.

The TIFA has been used on many different types of terrain in this District, including irrigated pastures, sewer farms, river bottom land, and in fogging whole towns; it has also been used very effectively in large buildings. Using the TIFA in populated centers has been a tremendous asset to us in public relations with our supporters in the many towns which are a part of the Consolidated Mosquito Abatement District.

The following is some information on the treatment of one hundred and sixty acres of irregularly surfaced, irrigated pasture. This area was treated on October 30, 1947, for the emergence of adult *Aedes nigromaculis*.

This was not an ideal irrigated pasture; no refined leveling had been accomplished, leaving the field with a disrupted natural drainage. So disturbed was its surface that many clod and potholes existed throughout its entire area. To irrigate one section adequately, it was necessary to flood another. This practice creates a proper environment for the incubation of *Aedes* eggs, and the maintenance of an ideal habitat for larval survival. Areas of land remain moist or wet as the case may be, from one flooding until the next. The close location of an abundant food supply (well-fed cattle) increased the well-being of the mosquitoes, as well as their fertility. Previously no treatment had been given this area, inasmuch as it is outside of the Consolidated Mosquito Abatement District's necessary control area. It was intended to use this acreage as an experimental ground for our equipment all during the year, even though it was much beyond the District.

In attempting control treatment of this area it was determined to try to ascertain the efficacy of the TIFA as an adulticidal fog generator, at a distance of one quarter mile from the site of application.

Pre-treatment inspection of the farm land revealed an over-all infestation of from fifteen to twenty adults landing on the visible side of the operator's pants leg at a time. Moving ten to fifteen feet away would again excite another average of fifteen to twenty mosquitoes to land; this observation was consistent throughout the one hundred and sixty acres of irrigated pasture land.

For the purpose of treating this land the TIFA mounted on a jeep was used, the insecticidal solution being fed from a ten gallon milk can installed where the right front seat is usually placed.

A five per cent technical grade DDT in diesel oil was adjudged most suitable as an insecticide, and this was used both in trials, test runs, and in the actual experiment. The TIFA was driven for one mile along the road adjacent to the infested property, covering it with one swath in two sections, each using ten gallons of material, making a total deposition of twenty gallons of the five per cent DDT in diesel oil. The total operating time was twenty minutes, with the jeep traveling at three miles per hour during the time of application. It was noted that the "lay" of the fog was ideal, i.e., it would remain on or near the ground, rolling along, with a "hang" right next to the surface. Sometimes when the fog is used without the proper ratio of air temperature and ground temperature, it will float anywhere from six inches to six feet above the surface; in fact, one can stoop and look under the fog layer. It truly forms a blanket. There was no, or very little wind, and the fog drifted but very slowly, remaining visible for over an hour afterward.

The irrigated pasture land was given a twenty-four hour post-treatment inspection the next day, when weather conditions were approximately similar, and no adults were observed. Throughout the mile long strip, and to a depth of one quarter of a mile, the mosquitoes were apparently completely controlled. At distances greater than one quarter of a mile the surface features changed abruptly, therefore no observations were made on the back section, beyond this arbitrary limit.

The relative humidity at the time of application was 58 °, the temperature was 68 ° F. The wind velocity measured

nearby was 2 miles per hour. Fuel pressure on the TIFA was 50, and the formulation number was 40, with the air pressure at 4. The maximum air temperature during the day was 73 ° F., and the minimum air temperature was 50 ° F., with mean temperature of 62 ° F.

Work in the Consolidated Mosquito Abatement District with the TIFA was at its peak during July, August, September and October. Through these four months the District used 1,235 gallons of the insecticidal material, 5 per cent DDT in diesel oil, taking 284 hours of labor to cover 11,140 acres. At this rate of application we used .11 of a gallon per acre, or .04807 pounds of DDT per acre. This is at a cost of 11½¢ per acre for labor and materials. There were times when greater and lesser amounts were used, as when only a few acres were covered by fog at a time; this, however, was mainly due to our early experiments having been worked out through trial and error. In operating the TIFA, we had to learn just the proper time, or rather the proper combination of temperature, humidity, wind, and of especial importance, the relation of temperature between the air and the ground. The question might be raised that October was rather late in the year to be citing an experiment designed to measure the far-reaching effect of the TIFA. In reply, we have this from the weather man: "The month of October was warmer than usual with a mean temperature of 65.2 ° F., 2.9 ° above normal. The highest temperature of the month, 100 ° F., set a new record, surpassing the previous high mark of 99 ° F. set in 1933."

For the period of operations from July 3 to November 1, 1947 the only mechanical trouble encountered was maintaining the recommended 75 pounds of fuel pressure. Upon the recommendation of the field representatives in this area, the orifice on the fuel injection pipe was changed, and the fuel pressure easily maintained at 50 lbs. thereafter. Another difficulty encountered then was the accumulation of dirt in the fuel by-pass or regulating valve.

A minor trouble worthy of mention was the rapid accumulation of carbon at the fog discharge nozzle. This was possibly due to the material used, which has been mentioned above.

Cost of upkeep was minimal, less than one half of one per cent of the initial cost of the machine, for parts. Structurally the TIFA remained sound, despite the necessary shock, bump and jolt, and shaking over rough ground—plus many miles of travel over our widespread District. No apparent damage was found in the delicate gauges and valves, in spite of this usage.

Observation indicated to us that the early morning hours, just at dawn, were best for the operations, both in effect on mosquitoes, and to take advantage of the thermo-dynamic principles involved in the fog's application.

The ease of handling and simplicity of its operation made it possible to use the TIFA even in those early hours at dawn, or in the evening just at dark. A more elaborate machine would have defeated its purpose if used at these times, as light would be needed to make adjustments. With the TIFA, however, the operations were uninterrupted, with only our headlights to illuminate the way.

With six hundred and forty square miles of territory to control by our 21 operating units, and a very successful season behind us, it is felt that a portion of the gratitude often expressed is due the assistance provided by our extensive use of the TIFA.

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NOTES ON CERTAIN SPECIES OF MOSQUITOES FROM DELAWARE COUNTY, PENNSYLVANIA

ROBERT M. STABLER [1]

In June, 1946 Wilson, Barnes, and Fellton published "A list of the mosquitoes of Pennsylvania with notes on their distribution and abundance." This is an excellent account. It is based partly on data from Delaware County, Pa., which included the County Commission's trap records and personal communications, and a previous report by the present writer (1945). Certain of their statements need minor revision, however, in the light of Delaware County's complete records for the years 1944, 1945 and 1946. The present notes are made from these records, principally those of the summer of 1946.

Especial thanks are due Major Russell W. Gies, Executive Secretary of the Commission. For the continued help of Richard L. Jones, Joseph E. Wickersham, Guy Kennedy, and James J. Walsh, the writer is most grateful.

Delaware County, Pennsylvania, has an area of some 184 square miles, embracing a population of about 350,000 persons (Gies, 1944). It possesses large areas of marsh land south of Philadelphia, and between Darby Creek and the Delaware River. From these low marshes, it extends into uplands of towns, woods, and farms. The County Mosquito Commission annually operated ten New Jersey light traps over this area from June 1st to October 1st. The catches were examined almost daily, and data obtained therefrom were added to other observations on mosquito abundance. Most of the statements in these notes refer to female mosquitoes only.

The writer will comment on the mosquito species in the order in which they were listed by Wilson, Barnes, and Fellton (1946), omitting those, however, which warrant no comment here.

Aedes canadensis. This was a common species in Delaware county, being a very troublesome biter in wooded areas. It was decidedly uncommon as a trap invader, however, and was taken in small numbers in June and July only.

Aedes cantator. This mosquito was a vicious biter (Stabler, 1945), and in many places was the earliest spring feeder. It bred freely in the flooded freshwater marshes of Tinicum Township. In July, 1944, these marshes, involving huge areas of inundation from abnormal rainfall and broken dikes, were producing this mosquito by the countless billions, every dipper yielding 200–300 larvae and pupae. Wilson, Barnes, and Fellton state that "it breeds in the brackish coastal marshes," not suggesting its freshwater possibilities.

Aedes cinereus. Though not abundant in Delaware County, this species was not rare. It was taken in six of the ten traps, in July and August only, and was a not infrequent biter.

Aedes sollicitans. That this striking form bred in Delaware County was never proven by the writer, despite constant larvae identification and rearing. As an adult, it was not a rarity, though it was in no place abundant in recent years. It was commonest in the more southern sections of the County, suggesting invasion from the brackish areas of the Delaware River to the south.

Aedes stimulans. Wilson, Barnes, and Fellton state that *A. stimulans* is "probably common throughout much of the State." In Delaware County, it was de-

[1] Colorado College, Colorado Springs, Colorado (formerly of the Delaware County, Pa., Mosquito Extermination Commission).

cidedly uncommon, and has been so for at least ten years. For five years no single specimen was taken by light trap. The writer took two biting females in three years.

Aedes taeniorhynchus. This form is rare indeed, less than a dozen specimens being taken at only three sites in the past three years.

Aedes triseriatus. Although not abundant in our traps, a trip to the woods found the individual quickly surrounded by this tree-hole species. Larvae were also taken in abundance from wooden tubs in widely scattered areas.

Aedes trivittatus. Taken in six of the ten traps, *A. trivittatus* did not appear to be abundant in the County. In certain local areas, however, it was excessively numerous. One such spot was frequently visited by the writer, and the hordes which promptly attacked nearly carried one away! A light trap only ¼ mile from this spot, however, took only an occasional specimen. Indeed, a retreat of only 100 yards from this site, even at dusk when they were most active, found most of the mosquitoes left behind.

Aedes vexans. This is the mosquito pest of Delaware County. It was, in certain localities, at times almost unbearable, and its eradication would at once reduce the County's mosquito problem to one of mere routine control. The flooding of the County's hundreds of acres of low lands produced *A. vexans* in, at times, astronomical numbers.

Anopheles barberi. Wilson, Barnes, and Fellton state that they have records of this species "from only two localities in the State," both "from privies." Neither is from Delaware County. The writer has taken two females there in light traps in three years, and has hand-caught three males, one under a bridge and two in a shack in the woods. It is a rare type there.

Anopheles crucians. Classed as a "relatively rare" species in Pennsylvania, *A. crucians* does not seem to be so in certain parts of Delaware County. In fact, the traps showed more of them in 1946 than of *A. punctipennis,* a very widespread, abundant anopheline there. This may be serious in a county with Delaware's population because of recent evidence that this species *(crucians)* is important as a vector of malaria.

Anopheles quadrimaculatus. As stated by Wilson, Barnes, and Fellton, this queen of eastern U. S. malaria transmitters is not common, at least in Delaware County. Certain resting places would generally yield a few specimens, but collections were very small.

Anopheles walkeri. "Only four localities" for this species were given by Wilson, Barnes, and Fellton. It is rare in Delaware County, only seven specimens having been trapped there in three years.

Culex apicalis. Though not a feeder on man, this species goes into light traps more abundantly than many realize. An actual tabulation from one trap in Delaware County showed 23 per cent of a month's catch of *Culex* mosquitoes to be *apicalis.*

Culex erraticus. The two females of this species taken by the writer were sent to Barnes for identification. In their paper, Wilson, Barnes, and Fellton list them as being one from "Norwood" and the other from "Philadelphia, (Tinicum)." The latter location as given is rather misleading as this second female was from the Tinicum trap, located in Tinicum Township, directly across Darby Creek and its marshes from Norwood. This is quite some distance from Philadelphia.

Culex pipiens. Wilson, Barnes, and Fellton state this to be "probably the most important of the pest mosquitoes in Pennsylvania." This is certainly not true of Delaware County. There, where successive downpours give rise to successive crops of *vexans,* the great areas of lowlands produce mosquitoes which make outdoor work in some sections virtually impossible after dusk.

Culiseta melanura. Again listed by Wilson, Barnes, and Fellton as "appar-

ently a rare species in this State," with only two locations given (Chester and Norwood in Delaware County). In 1946 in this County, this form was trapped in Chester, Linwood, Norwood (23♀♀), Ridley Park, Sharon Hill, and Tinicum. A total of forty was trapped, and numerous females were taken biting. It is not rare there.

Orthopodomyia signifera. Stated as having "been taken in only two localities" (Glen Mills and Philadelphia), the writer trapped 66♀♀ in 1946 from Chester, Glen Mills, Linwood, Media, Norwood (43 specimens), and Sharon Hill. This species is not abundant, but certainly is not rare, in Delaware County.

Psorophora confinnis. This is listed as being probably of not much importance in Pennsylvania. In 1946, 229♀♀ were trapped, and in some locations it was a quite annoying mosquito. In years past Delaware County catches have run into the thousands for this species.

Psorophora ferox. Wilson, Barnes, and Fellton state that this striking species "is extremely rare in Pennsylvania." The writer's data do not bear this out, at least for Delaware County. Eight females were trapped in 1946 in Bryn Mawr, Norwood (6), and Swarthmore. One or two biting females could nearly always be taken in a particular patch of woods near Glen Mills.

Uranotaenia sapphirina. This beautiful little mosquito is widespread, though not abundant, in Delaware County. In 1945, 190♀♀ were taken in eight traps. Wilson, Barnes, and Fellton describe it as "only recently reported from the State." The records of the Delaware County Mosquito Commission report it as early as 1936.

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A FAR SOUTH RECORD OF *Anopheles quadrimaculatus* SAY IN FLORIDA[1]

D. C. THURMAN, JR.[2]

The first known record of *Anopheles quadrimaculatus* Say in Monroe County, Florida was made by the writer, based on the collection of four males and eight females, July 18, 1946. This discovery made in connection with statewide anopheline density studies being carried out in the state is a record in the last county from which *A. quadrimaculatus* Say was unreported in Florida.

These specimens were taken resting in an abandoned trailer on Florida Highway No. 27 at Pine Crest, a community represented at the present time by one vacant house. This collection on the mainland of Monroe County is believed to represent the farthest southwest limit of breeding of *A. quadrimaculatus* Say in the state. Pritchard *et al* (1947) did not report this species from the Florida Keys. An extensive anopheline survey of the Florida Keys and the Cape Sable area during the winter of 1946–1947 failed to produce any specimens of this anopheline.

[1] A contribution from the Florida State Board of Health, Jacksonville, Florida and the Communicable Disease Center, Atlanta, Georgia.

[2] Senior Assistant Sanitarian (R), U. S. Public Health Service.

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NOTES ON THE ABILITY OF MOSQUITO PUPAE TO SURVIVE EXPOSURE TO AIR

CHARLES OTTO MASTERS [1]

The tests were made in Assam, India during 1944 with the pupae of *Culex (Culex) fatigans* Wiedemann 1828. Because of the nature of the soil in the area very often mosquito-breeding spots would dry up suddenly leaving eggs, larvae, and pupae exposed to the moist air until the next rainfall. In these particular tests, the author was concerned only with the ability of the pupae to survive the partial drying-out.

Conditions were duplicated in the laboratory using petri dishes, filter paper, and rain water. The pupae were gathered in the field. By means of a pipette, they were transferred to the surface of the moist filter paper in the dishes which were covered and placed on the laboratory tables. The indoor temperature ranged around seventy-five degrees Fahrenheit. Records were kept of the number (and percentage) of mosquito adults which eventually emerged. In each case the test was completed within one week. Data were as follows:

Test Number	*Number of Pupae Placed in Dish*	*Number Emerged*	*Per cent*
1	5	3	60
2	4	4	100
3	5	4	80
4	53	53	100
5	10	6	60
6	65	38	58
		(remaining pupae apparently drowned under the paper where they had become caught)	
7	56	56	100
8	27	24	88
9	40	33	82
10	35	23	65
11	49	40	81
12	40	33	82
13	31	26	84
14	63	58	92
15	35	31	88
16	32	26	81
17	34	32	94
Totals	584	490	83

From the data secured, it seemed the mosquito pupae did not require a water medium such as was required by the eggs and larvae for complete development.

[1] Western Reserve University, Cleveland, Ohio.

MALARIA CONTROL IN GUAYARAMERIN, BOLIVIA [1]

THOMAS A. HART,[2] JEANELLE H. HART,[3] AND EDUARDO SARACHO-LOPEZ [4]

At the beginning of 1943, as part of a cooperative health program between the governments of the United States and Bolivia, the Health and Sanitation Division of the Institute of Inter-American Affairs began a malaria control project in Guayaramerin.

Guayaramerin is located across the Mamore River from the terminus of the Madera-Mamore Railroad on the Bolivian-Brazilian frontier. With a population of 1,300, it is an important frontier town and a center of rubber development. Located in the equatorial lowlands its climate is hot and humid. Guayaramerin may be reached by air, from east or west; by rail from Porto Veljo, Brazil; and by water through Brazil or Bolivia. Transportation by air is costly, by rail or river launch it is slow and difficult.

Original investigations in Guayaramerin revealed a high endemicity of malaria. The parasite rate for children under twelve years of age ranged between 17 per cent and 20 per cent; the splenic index was 85 per cent. The actual malaria vector is still a matter for conjecture. However, Anopheline mosquitoes of the following species have been collected: *A. darlingi* Root, *A. triannulatus* (N.&P.), *A. oswaldoi* (Perry), *A. rondoni* (N.&P.), *A. mediopunctatus* (Theob.), and *A. albitarsis* Lynch Arrib. Identification of all specimens mentioned in this paper was made by Dr. Alan Stone of the U. S. National Museum.

The average adult Anopheline mosquito density per house was four. No records are available for the larval density before 1946. Early control operations consisted of leveling the unpaved dirt streets of the town, putting in drainage ditches and using paris green as a larvicide on temporary bodies of water. At the same time, atabrine was distributed free to the entire population. While these methods were partially effective, a fifty per cent morbidity, most of which was probably due to malaria, pointed to the need for additional control measures.

The use of paris green was continued and more extensive drainage work was undertaken. The campaign for the atabrine suppression of malaria in the population was intensified. A dosage of three yellow atabrine pills per week kept the rubber sap gatherers in the tropical rain forests and the town's people at their daily occupations. However, there were continued relapses because the population never became educated to the necessity of the routine use of atabrine as a suppressive.

These methods were continued during the years 1943, 1944, and 1945 and construction of a modern hospital was completed (Fig. 1). Nevertheless, the end of the year 1945 saw no substantial reduction in morbidity due to malaria.

It was about this time that the new product, DDT, became available for use in the field. In May 1946, for the first time in Bolivia, DDT was applied in the

[1] Material from this paper was presented by Mr. Thomas A. Hart at the first Regional Inter-American Conference of Sanitary Engineers held in Rio de Janeiro, Brazil, June 10–15, 1946.

[2] Director of Malaria Control in Bolivia for Institute of Inter-American Affairs 1945–1946. Now Professor of Biology and Dean of the School of Arts and Sciences, Roosevelt College, Chicago, Illinois.

[3] Laboratory technician for the Rockefeller Foundation Laboratory in Cochabamba, Bolivia (1946).

[4] Chief Malariologist for the Bolivian government public health service known as the Servicio Cooperativo Inter-Americano de Salud Publica.

FIG. 1. Guayaramerin Hospital. Completed in 1945. A modern building of brick and concrete.
FIG. 2. First house in Guayaramerin to receive DDT residual spray treatment.
FIG. 3. Typical Guayaramerin house. Adobe, with straw thatch.
FIG. 4. A modern Guayaramerin building. The Royal Hotel.

treatment of an entire town, i.e. Guayaramerin. The buildings there are of various designs and constructions. There are houses of split bamboo with grass and palm thatched roofs some of which are plastered with mud and whitewashed inside and outside. There are also buildings of adobe and some houses of modern construction (Figs. 2, 3, 4).

Oil soluble DDT was used in the first treatment of Guayaramerin for these reasons: availability, more knowledge by those concerned in the use of oil soluble than water dispersible DDT at that time, and the fact that a supply of surplus fuel oil was then available in Guayaramerin. Operations began on May 4, 1946. Wall surfaces totaling 64,528 square meters in 203 houses, were treated at an average cost of 2.5 cents per square meter and approximately $8.20 per house. These cost figures include air freight for all materials, air passage for all personnel, and the price of $1.00 per pound for DDT and 50 cents per gallon for fuel oil. A residual of 1.63 grams per square meter remained. Of the 203 houses which were treated, 50 had been chosen for inspections before and after treatment. Inspections of fifteen minutes duration per house was made at six thirty P.M. the evening preceding treatment and again one week later. The original inspections netted two hundred adult mosquitoes, an average of four per house. The post treatment inspections netted only sixteen mosquitoes.

Practical spraying apparatus for field use was evolved using nozzles from New Idea Knapsack Sprayers and tanks and hose of Aeroil Burners (Fig. 5). The optimum spraying effect was secured with 30–35 pounds pressure in the tank and

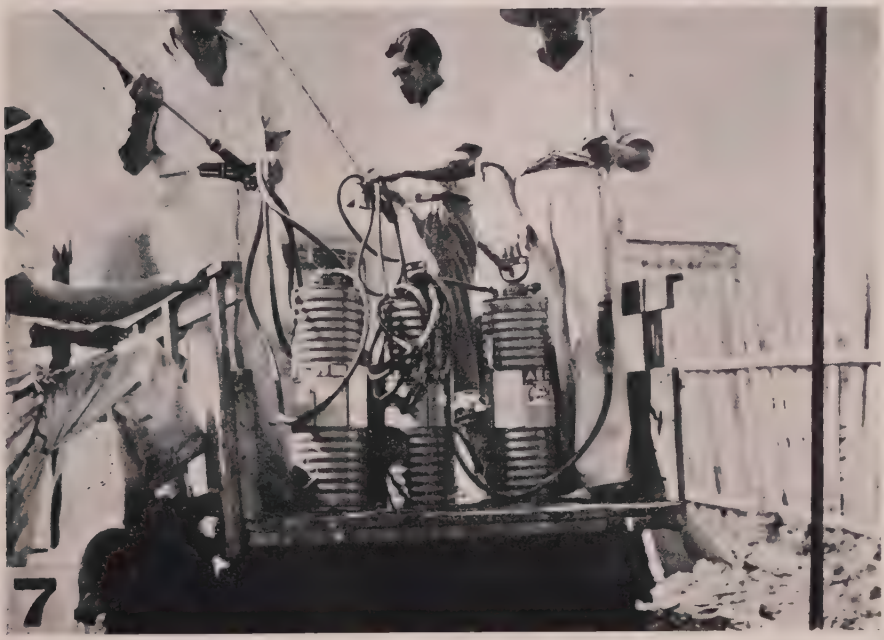

Fig. 5. Dr. Saracho Lopez, hatless, helping to mix and pour first DDT solution into aeroil tank.
Fig. 6. House furniture covered with sheets to prevent spotting with oil.
Fig. 7. Spray crew and equipment.

the use of the smallest aperture of the nozzle held about eighteen inches from the wall. A fan-shaped spray of fine particles of oil was applied to the wall, from floor to ceiling, then from ceiling to floor by continuous vertical motions in even adjoining swaths. For painting screens standard three inch paint brushes and buckets filled with the spraying solution were used.

Seven ounces of 100 per cent DDT powder per gallon of oil gave the 5 per cent solution which was used for spraying operations. After removing three gallons from a 53 gallon drum of No. 2 Diesel oil (fuel oil) 22 pounds of DDT powder were added. With the solution from the drum the sprayer tanks were two-thirds filled, leaving the remaining space for air pressure.

The personnel for the spraying operations included one foreman and two spray crews. Each crew was composed of four men (Fig. 7). Two men operated the hand sprayer, one man handling the hose and nozzle, the other managing the sprayer pump. The number three men were detailed to advise the occupants of the proximal house of the approaching crews and to help prepare the house for spraying operations (Fig. 6). The number four men followed with an additional sprayer to exchange for the emptied one. Spray crews were taught by example and actual practice to apply the spray at the rate of approximately 30 square meters per minute. Turns were taken in these duties and changes were frequently made in order not to burden any one man with too long a period at the most difficult job. The handling of the spray nozzle was considered by the laborers to be the most difficult and tiring work. No allergic reactions or other ill effects were observed among the crews as a result of handling or being exposed to DDT oil solution.

From house to house, and from room to room, the personnel of the malaria control organization effected these measures. This use of DDT produced quick, positive results. There were fewer adult mosquitoes in the houses; there were fewer people ill from malaria. Plans were immediately made for repeating the treatment at six month intervals.

In the meantime, water soluble DDT had become available and was used in all subsequent operations in Guayaramerin. The second treatment took place between September 30 and October 11, 1946. 206 houses were treated involving a total wall surface area of 68,371 square meters, leaving an average residue of 4.33 grams per square meter. At a price of 50 cents per pound for water soluble DDT in Bolivia, the cost per square meter was 1.5 cents, averaging $4.85 per house. Houses inspected prior to this treatment had revealed a grand total of 3 adult mosquitoes.

Anticipatory inspection of scattered houses prior to the May 1947 treatment revealed few adult mosquitoes. Selection was then made of 46 houses on the periphery of the town close to the natural breeding places of the mosquitoes. This inspection netted 94 adult mosquitoes, an average of two per house.

160 houses were treated with water soluble DDT. The total wall surface covered was 42,308 square meters. A residual of 4.35 grams per square meter remained. This operation cost $2.90 per house. The noticeable reduction in expenses was due to the fact that the entire labor force for this operation was furnished gratis to the project by the Mayor's office and the military detachment.

The beneficial results of this program were so dramatic and self evident that no special educational campaign was necessary. The offer of free labor by the Mayor's office and the military detachment were evidences of the good will engendered. The people of the town were cooperative. They were interested from the first in having the program made a regular public health service.

June and July 1947 inspections of 50 houses each month revealed no adult Anopheline mosquitoes. The August inspection of 150 houses resulted in the capture of 21 adult Anopheline mosquitoes.

Inspections in September, October and November 1947 of 50 houses per month again revealed not a single adult Anopheline mosquito. Because of these results the routine October DDT residual treatment of houses has been postponed deliberately for an indefinite period or until inspections reveal the presence of adult Anophelines, necessitating additional DDT applications.

Since the initial DDT application in May 1946 there has been no epidemic of malaria in Guayaramerin. The number of cases at any given time has not exceeded 10 with the exception of the month of August 1947 when 29 malaria patients were treated in the Guayaramerin hospital. However, of this number more than half were not native residents.

Since the records of larval density became available they have revealed an average of 10 larvae per dip. This number fluctuates according to the seasons, the largest number of larvae being present between the wet and dry seasons.

The treatment of houses with DDT during the past two years has had no noticeable effect on larval density in natural breeding places surrounding Guayaramerin. This fact has revealed the necessity for the use of a larvicide. Preliminary trials with water soluble DDT in concentrations of 3, 5, 10 and 15 per cent showed that it precipitated out of solution when used on natural breeding places. Oil soluble DDT of equal concentrations has proved to be more effective as a larvicide.

Future malaria control operations in Guayaramerin will consist solely of the application of oil soluble DDT as a larvicide. This will be applied to all natural breeding places for an area of one mile around the periphery of the town. This procedure will decrease considerably the cost of malaria control and simplify the operations. It will eliminate the necessity for the presence of professional personnel after the training of local workers.

Summary

The history of Malaria control in Guayaramerin, Bolivia since 1943 is traced. The preliminary measures used and the later treatments with DDT are described. The future malaria control program will consist of the use of oil soluble DDT as a larvicide.

Resúmen

Se trata de la historia del control antipaludico en Guayaramerin, Bolivia desde el año 1943. Se describen los métodos introductorios y los tratamientos subsequientes con el DDT. El control antipaludico del futuro usará el DDT soluble en aceite como larvicida.

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CONTROL OF SALT-MARSH SAND FLIES AND MOSQUITOES WITH DDT INSECTICIDES

W. G. BRUCE AND E. B. BLAKESLEE [1]

Salt-marsh sand flies and mosquitoes hinder real-estate development in the coastal areas of the South Atlantic States. The control of these insects has been aided to a great extent by the use of new insecticides and modern equipment for dispersing them.

In 1930 Federal funds were appropriated for the study of sand flies in these areas. A laboratory was set up for this purpose at Charleston, South Carolina. A hotel built in 1928 on Wilmington Island, 10 miles from Savannah, Georgia, at a cost of approximately two million dollars (Fig. 1), was then in the hands of receivers because so many guests had been driven away by these insects. It had been opened only at intervals since its construction because of extreme insect annoyance. The receivers made the property available for sand fly control studies in 1932. Insecticides available at that time made chemical control impractical, and studies were discontinued in this area in 1935.

This hotel was selected for the inaugural meeting of the International Monetary Conference, March 8 to 22, 1946. The dates for the meeting were at a time of the year when salt-marsh sand fly annoyance was greatest. The management requested emergency aid from the Bureau of Entomology and Plant Quarantine in the control of these pests.

Wilmington Island consists of 3,942 acres of dry ground surrounded by 7,718 acres of marshland. A marsh of nearly 75 acres lies to the north of the hotel property, separated from it by a fringe of trees about 1,000 feet wide. An 18-hole golf course lies to the east, and is partly wooded. An area to the south is thickly timbered. The Wilmington River borders the hotel property on the west. A tidal creek bisects the island from the east.

The emergency situation was met by the use of three general types of control —residual coatings, thermal aerosols, and airplane sprays.

A residual coating consisting of an oil solution containing 5 per cent of DDT was applied by mopping to all window and door screens. The same solution was applied to screen hoods fitted over all outdoor lights. Similar coatings of a xylene emulsion containing 2.5 per cent of DDT were applied to the garage, the kennels, and the understructure of the boat dock. Outside wall surfaces of the hotel and servants' quarters and surrounding shrubbery were sprayed to a height of about 12 feet with a water suspension containing 1 per cent of DDT. The walled front of the swimming-pool terrace and the balustrade around the pool were sprayed with a 2.5 per cent DDT suspension.

Thermal aerosols, or fogs, produced by a thermal aerosol generator loaned by the U. S. Public Health Service were applied at intervals over all, or parts, of the grounds, golf course, and adjacent wooded areas. The aerosol formulation was 3¾ pounds of technical DDT in 1 gallon of commercial xylene and 4 gallons of SAE No. 10 motor oil. Operating temperatures ranged from 450° to 600° F. The latter temperature proved most effective. The generator was not entirely satisfactory and appeared to require improvement in design.

An airplane sprayed the entire area twice on March 8 with 10 gallons of a 20

[1] United States Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine.

The writers express their appreciation for the assistance of the U. S. Public Health Service.

per cent DDT-oil solution and a few days later with the same quantity of a 30 per cent DDT-oil solution. The rates of application were estimated at 0.1 and 0.15 pound of DDT per acre. The applications gave almost total relief of sand fly annoyance during the time of the conference. The swimming pool, terrace, golf course, and game areas were used by the guests without material discomfort. No annoyance was evident inside the hotel.

It is difficult properly to evaluate each of the control measures employed on this work. Owing to the relatively light sprays of DDT applied by airplane, the value of these applications is now considered doubtful. The aerosol fogs proved of sufficient usefulness, as a last-minute emergency, to be classed as of second value. Flights of sand flies came into the protected areas with light winds on several occasions. When atmospheric conditions were favorable, the entire area was fogged. Post-fogging checks showed that sand flies had been satisfactorily controlled. The period of protection ranged from 24 to 48 hours. Residual applications are now considered to have been the most effective of the several methods tried.

The management of the hotel was delighted with the results of these experiments, and asked for a continuation of the control work, but this was not possible. However, it was recommended that a high-speed, blower-type sprayer (Fig. 2) be purchased for the application of oil solutions or emulsions containing 5 per cent of DDT, and that these materials be applied over the entire property at about 2-week intervals during seasons of insect annoyance. These recommendations have been carried out for nearly 20 months.

Results from these efforts have been entirely satisfactory. The hotel has remained open every day since the conference, and no insect annoyance has been reported. It has already become necessary to enlarge the hotel accommodations.

Fig. 1. (Insert) View of General Oglethorpe Hotel, Wilmington Island, Savannah, Ga.
Fig. 2. High-speed, blower type sprayer in action on grounds of General Oglethorpe Hotel.

NEWS AND NOTES

One of the most interesting, and best attended, meetings of the National Malaria Society, was held December 2–4, 1947, in Atlanta, Ga. The meeting was held conjointly with the 43rd annual meeting of the American Society of Tropical Medicine and the 14th annual meeting of the American Academy of Tropical Medicine. This was the first time these organizations were unable to meet with the Southern Medical Association, because of lack of accommodations.

Dr. E. Harold Hinman, Wilson Dam, TVA, was elected President of the organization for 1948.

Several papers delivered at the meeting were of special interest to mosquito control workers. Among such papers were: "New plans for Vector Control in California," by Arve H. Dahl, "Effects of Routine DDT Mosquito Larviciding on Wildlife," by Clarence M. Tarzwell, "Some Factors Influencing the Residual Effectiveness of DDT and Chlordane in *Anopheles* Mosquito Control," by K. D. Quarterman, "The Influence of the Moon on Lighttrap Collections of Mosquitoes in Puerto Rico," by Harry D. Pratt, "Factors Influencing Crepuscular Activity of *Anopheles albimanus* in Panama," by Harold Trapido, "Flight Range Studies on *Culex tarsalis* Coq. in California," by W. C. Reeves, B. Brookman, and W. McD. Hammon, "What's Happening to Malaria in the USA," by J. M. Andrews, and "Blueprint for Malaria Eradication in the USA," by J. M. Andrews, and W. E. Gilbertson.

The first year of the U. S. Public Health Service five year malaria control plan is over, and reports indicate that there is the same feeling of optimism now as when it was formulated.

The Presidential Address by Dr. George K. Strode, was read by Dr. George Shattuck. This paper discussed the influence and effects of climate on the health of man. A consolidation of the three Associations was also discussed by Dr. Strode in this paper. A committee representing each of the Associations was appointed to study such a consolidation.

The Theobald Smith Gold Medal of the George Washington University was presented to Dr. Clay G. Huff, Naval Medical Research Institute, Bethesda, Md., whose address was "Exocrythrocytic Stages of Malaria Parasites."

The many gracious courtesies extended by the personnel of the Communicable Diseases Center of Atlanta were greatly appreciated by those in in attendance. A dancing party at the Center was enjoyed by a large number of visitors.

H. H. STAGE

NO FLIES ON IDAHO—BOAST OF MAGAZINE DIGEST DDT ARTICLE. A combined digest of two publications concerning the recent anti-housefly campaign in the State of Idaho is to be found in the August, 1947, issue of Magazine Digest, which should be read by those districts contemplating the extension of their mosquito control measures to include houseflies.

MOSQUITO BUZZ

A REVIEW OF MOSQUITO CONTROL IN CALIFORNIA. Beginning with the January 15, 1948 issue of *Mosquito Buzz*, a chronological review of the growth of mosquito control in California will be featured. Beginning with the Marin County MAD, the first Mosquito Abatement District to be organized in California, and proceeding in chronological order, the present 39 mosquito and pest abatement districts, none of which has ever been dissolved, and prospective new districts as organized, will be featured, one district in each issue. The project will, of necessity, run for the better part of four years. MOSQUITO BUZZ

FIRST QUARTER SUBVENTION SUMMARY PROVES INTERESTING. Based on operation reports of twelve of the seventeen mosquito control agencies which have thus far submitted complete information for the first quarter of the current fiscal year, there remains no question to the frequently stated conclusion that mosquito control in California is "big business."

Buck Buchanan has come up with the following figures for the first quarter: Larviciding—30 tons of DDT and 3,264 gallons of oil were consumed in treating 325 square miles of water surface, 2,116 cesspools, 16,671 catch basins, 2 miles of street gutters and 8,571 miscellaneous containers. 32,242 man hours and 484 plane hours were needed to accomplish this work. Adulticiding—11 tons of DDT were used in addition, for approximately 6½ square miles of building surface and about 700 square miles of the great outdoors, both requiring the expenditure of 11,000 man hours.

The twelve districts supplying the figures cover a collective area of 6,454 square miles and their vehicles covered a total of a little over one-third of a million miles in completing these and other services for their constituents.

Statistically speaking, the average district of the twelve contains an area of about 538 square miles, has a staff of about 15 persons working a 44-hour week. Two-thirds of the total man hours are expended on rural operations, one-seventh on urban operations and one-fifth on unclassified work.

If complete figures on all thirty-nine MADS, plus the several Health Departments performing mosquito control operations, were obtainable, there would be an even more impressive summary for "Buck" to present with or without statistics.

MOSQUITO BUZZ

HOW BIG ARE YOUR MOSQUITOES? ALAMEDA CO. MAD KNOWS THEIRS. Ted Aarons, Entomologist of the Alameda Co. MAD, has done a bit of research into the displacement, expressed in milligrams, of the *Culex tarsalis* mosquitoes collected in that district. The huskiest female among those weighed on a highly sensitive balance, tipped the beam at 1.5 m.g., with the lightest weighing 0.1 less. By calculation, it follows that 19,551.4 mosquitoes are required to make one ounce. To complete the study, a proboscis was severed from the body and weighed; it taxed the scale in showing 0.1 m.g. Most everyone agrees that so little possesses a lot of authority. MOSQUITO BUZZ

MOSQUITO CONTROL EXPANSION CONTINUING AT A BRISK CLIP. To the approximately 15,000 square miles of area now under organized mosquito control, it is expected that approximately 2,000 additional square miles will be added by February 1, 1948, enabling this area to be included on the tax rolls for the fiscal year beginning July 1, 1948. Territory in Tehama County, Colusa County, Sutter County, Contra Costa County, Stanislaus County, Fresno County, Tulare County and possibly Los Angeles County represent the likely increase. During the year 1948, approximately 2,000 additional square miles of area are expected also to wage war on mosquitoes from territory in Glenn, Butte, Contra Costa, San Joaquin, Fresno and Riverside Counties. Looking forward to 1952, there could well be an additional 3,000 square miles of area added from various regions in California. This would then find the State with approximately 22,000 square miles of area under organized mosquito control. By 1952, the effects of the C.V.A. with its increased irrigation should be felt, making another estimate of future mosquito control area likely. MOSQUITO BUZZ

NEW JERSEY REPORTS ON THE USE OF AIRCRAFT IN MOSQUITO CONTROL WORK. Thomas D. Mulhern, Administrative Assistant, New Jersey Agricultural Experiment Station, sent a report to the Asheville conference entitled: "A large scale emergency application of DDT by airplane to destroy immediately an intense infestation of mosquitoes, and to subsequently keep mosquitoes under control by the residual effect of the DDT on foliage and other exposed surfaces in the treated area." Extracts from the article follow:

"The region about Carneys Point, Deepwater Village, Penns Grove, etc., had according to local reports become infested with mosquitoes in April and early May, 1945, and great annoyance had resulted throughout the early part of the summer, increasing as mid-summer approached. During June and July my investigations showed the principal breeding places to be at Carneys Point; that both salt marsh and fresh water species were breeding prolifically; that there were some anopheles mosquitoes breeding here; that the salt marsh species were biting freely both at night and in the daytime, while the fresh water species (principally the common house mosquito) were active principally at night. A wide variety of breeding places were found on the tract of approximately 1000 acres occupied by a powder plant, including two fresh water streams bordered by swamp areas of comparatively clean water. The mosquito infestation was very great indeed, as determined by inspection and confirmed by the operation of mechanical mosquito traps.

". . . two planes fitted with spinner disc spray units being used. The area sprayed was 938 acres, and included wooded areas, brush lands, grass land, cleared areas occupied by industrial buildings, marsh land, ponds and ditches, etc. More than 100 acres of land was water covered. The material was applied at the rate of 5 gallons per acre, the concentration being adjusted to give dosages in 3 different sections as follows:

Section 1—(100 acres) 2 lb. DDT/acre, in fuel oil No. 2.

Section 2—1.6 lb. DDT/acre, in emulsion.

Section 3—1.2 lb. DDT/acre, in emulsion.

"The spraying resulted in virtually complete elimination of larval and adult mosquitoes from the area treated, except for those in very well protected places. On all inspections made during the month following the spray treatment, adult mosquitoes were numerous outside the treated area, particularly along its southern border, but only an occasional live adult mosquito could be found by intensive day inspection in the treated area, indicating that the mosquitoes which were doubtless infiltrating from the surrounding area were being controlled by the residue of DDT."

Mr. Mulhern reported that a total of 938 acres were sprayed, with a flying time of 9 hours, 10 minutes; and that 4,500 gallons of spray emulsion were dispersed and 500 gallons of spray oil solution. He also stated that the foaming of the emulsion when it is loaded into the plane tanks can be prevented by introducing the emulsion into the bottom of the tanks.

"The costs of this operation, for airplane service and materials only, amounted to about $3500.00. The costs of this treatment were high, but justified in this instance by the emergency nature of the treatment." H.L.T.

PORTLAND AND MULTNOMAH COUNTY (OREGON) MAD REPORTS USE OF AIRCRAFT IN MOSQUITO CONTROL WORK. Mrs. Dorothy McCullough Lee, Commissioner of Public Utilities, Portland, Oregon, sent to the Asheville conference a detailed report on mosquito control in her territory. Extracts from this article follow:

"The City of Portland, Oregon, is at the confluence of the Willamette and the Columbia Rivers. Along these rivers, and particularly at

the juncture point, there is considerable lowland densely covered with brush and trees. In the spring, these rivers frequently rise 14 feet above their normal levels, and, as a result, approximately 35,000 acres in Multnomah County are flooded, making an ideal breeding ground for *Aedes vexans* and *Aedes lateralis* (=*aldrichi*) mosquitoes.

"During January of 1947, two Stearman PT-17 airplanes were purchased by our city. These planes are equipped with 220 H.P. Continental engines and are the type used by the Army and Navy as trainer planes. One of the airplanes is equipped with spray booms and wind-driven pump apparatus, and the other with an exhaust aerosol generator. The aerosol equipment also makes use of wind-driven pump equipment. A P-40 auxiliary gas tank was suspended between the landing gear of the aerosol airplane as an insecticide tank. This is a heavy aluminum tank holding 55 gallons and it makes an excellecnt installation. The tank is easily filled and cleaned and no leakage and spillage on the fabric of the airpane results, as is often encountered with the tank in cockpit.

"Walkie talkie radios, purchased from W.A.A., were used as a means of communication between aircraft and ground scout crews. The very dense cover in the breeding areas made the use of smoke signals, flags and other visible communication practically useless. The insecticide dispersed by both aircraft was identical, consisting of xylene, japonica oil, diesel oil and DDT. The rate of dispersal was 2 quarts per acre, 110 foot swaths at 80 mph.

"We find the airplane method of mosquito control to be very effective in our brushy flood-water breeding grounds. The cost of control from aircraft has proven to be less than the other methods used previously. The cost in this area, in spite of the fact that it was the initial year and therefore more costly than it will be in the future, was approximately ten per cent less than in previous years. Also, the results obtained by aircraft are far superior, regardless of expenditure.

"In conclusion I wish to state that the control of mosquitoes by aircraft has shown itself to be highly successful in this area. The people of Portland, as well as the property owners engaged in farming and similar enterprises in the rural sections of Multnomah County, have shown themselves to be highly pleased with the results of this year's work." H.L.T.

DELAWARE COUNTY (PA.) MOSQUITO EXTERMINATION COMMISSION REPORTS MOSQUITO CONTROL BY AIRCRAFT. Russell W. Gies, Scientific Director and Sanitary Engineer, Mosquito Extermination Commission of Delaware County, Media, Pa., has submitted the following information: "The Borough of Phillipsburg, Pa., had an application, at the rate of one gallon of 5 per cent DDT in oil, sprayed over 2,000 acres of the borough and surrounding areas in the middle of July, and it cost two thousand dollars. I am advised that the results were extremely satisfactory in the prevention of mosquito annoyance, there being practically no mosquitoes for approximately a month after the spraying; and for the balance of the mosquito season, mosquitoes were much less than normal, apparently due to the effect of the DDT. The principal type of mosquito that reappeared was *Mansonia perturbans* which was not apparently numerous in the early part of the season before the spraying."

GENERAL ELECTRIC NUCLEONICS PROJECT (RICHLAND, WASHINGTON) REPORTS MOSQUITO CONTROL BY AIRCRAFT. L. G. Koch, Sanitarian, Public Health & Welfare Section, Medical Department, General Electric Nucleonics Project, has reported on control operations for *Aedes dorsalis, A. lateralis,* and *A. vexans.* We quote from his letter as follows: ". . . those areas inaccessible to ground equipment were sprayed daily for 2 or 3 days by the aircraft, a treatment which was satisfactory but costly in aircraft time. In such instances, we later resorted to laying down a DDT residual barrier around the area and obtained results which were just as satisfactory; i.e. there being little significant difference in the eventual number of adults. An L-4 Piper Cub provided with a 35-gallon aluminum fuel tank is mounted in the position of the rear seat. A breaker bar is attached below the wing, fitted with six jets on each side, and serves as the dispensing means. A centrifugal propeller driven pump is attached to the feed line leading from the tank to the breaker bar. The pump forces the solution to the bar at about 30–35 pounds per square inch. As an added feature, a 24–30 inch section of radiator hose was fitted to the bottom of the fuel tank and attached to the fuselage. This served as an emergency 'dump' of the oil in case of trouble necessitating the pilot's lessening the load immediately. This also serves as a means of spraying long irrigation drainage ditches which were bordered with heavy vegetation. Under more or less ideal conditions, flights were made at an altitude of 30–50 feet at a flight speed of 60 mph, the swath width varying from 40–70 feet. A 5–7 per cent DDT solution was used almost exclusively and the areas treated at the rate of 2–4 quarts per acre. To accomplish adequate control this had to be repeated every 6–8 days.

"Our pilot estimated that for every pay load of 35–40 gallons sprayed, the time involved was one hour. The one hour included loading the adulticide, servicing the plane, including motor repairs, etc., and time in flight. We were fortunate in the fact that the air strip was located in the center of operations, a factor which reduced the flight time to a minimum."

TULARE (CAL.) MAD REPORTS ON MOSQUITO CONTROL BY AIRCRAFT. Rolland L. Henderson, Manager, Tulare Mosquito Abatement District, Tulare, California, has written about mosquito control by airplane as follows: "We have used an airplane this season for mosquito control. It's the first season we have used one and we are very enthused over our findings. We are using an N3N airplane equipped with a rather new and different type of spray equipment. It has a revolving 8" wire brush on the center trailing edge of each lower wing, revolved by a small propeller on a shaft at the leading edge of the wing. The liquid flows by gravity through a 1½" pipe, through the wing. A quick acting valve at the back of the brush controls the flow.

"We fly about 30 feet from the ground obtaining a 75 foot swath width, and obtaining, conservatively, a 95 per cent kill of larvae and adults. We use 24 per cent emulsible DDT and dilute that with water to 5 per cent DDT, which is the only type of solution we have used this year. We use 2 quarts per acre or 2/10 pounds per acre, which is 2 mg. per square foot of every acre. The cost of spraying is about 57½ cents per acre."

"MOSQUITOISM." CHAMPAGNE GIVES WAY TO DDT. Recently, Mrs. William F. Devlin, wife of the Mayor of Seattle, christened the good ship Culicide. The boat had been acquired by the City of Seattle for use in spraying mosquito breeding. Mrs. Devlin did the honors with a bottle of DDT.

From THE "SKEETER" (Oct. 1947)

MINUTES OF THE FIRST POST-LIBERATION MEETING OF THE PHILIPPINE SOCIETY OF PARASITOLOGY HELD ON SATURDAY, SEPTEMBER 27, 1947, IN THE MALARIA BUILDING OF THE U. S. PUBLIC HEALTH SERVICE, 25TH STREET, PORT AREA, MANILA

1. The meeting was called to order at 3:30 p.m. by President M. Tubangui.

Present:

1. Dr. Marcos Tubangui
2. Dr. Hilario Lara
3. Dr. Walfrido de Leon
4. Dr. Zacarias de Jesus
5. Dr. Mariano Basaca
6. Dr. Lope M. Yutuc
7. Dr. Eusebio Y. Garcia
8. Dr. Antonio Ejercito
9. Dr. Deogracias J. Cabrera
10. Dr. Trinidad P. Pesigan
11. Dr. Virgilio S. Rigor
12. Dr. Felicidad Albis
13. Dr. Francisco Gonzales
14. Dr. Antonio F. Acosta
15. Mr. Fraterno Abad Santos
16. Mr. C. M. Urbino
17. Dr. Francisco J. Dy

2. Dr. Tubangui opened the discussion by remarking that this was the first meeting of the Society after 6 years, and that all the records and papers of the Society were lost during the war. The passing of Dr. Candido M. Africa, who used to be Secretary-Treasurer of the Society, was deeply mourned. Dr. Tubangi also remarked that the Philippine Society of Parasitology is one of the few organizations which do not consider it necessary to have a constitution and by-laws; the members being bound together only by their professional interest and professional ethics. He announced that the Society is listed in the fourth (1942) edition of the "Handbook of Scientific and Technical Societies of the United States and Canada" with the following notation:

"1036. Philippine Society of Parasitology. Institute of Hygiene, University of the Philippines, Manila, P. I. President: Marcos Tubangui, Bureau of Science, Manila, P. I. Secretary: Candido M. Africa.
History: Founded August 20, 1930.
Object: To encourage interest and research in parasitology in the Philippines; and to acquaint members of the Society by means of informal papers and discussion, with activities of the local workers in parasitology.
Membership: Active members, resident or visiting workers in parasitology; Honorary, those nominated by the Executive Committee from parasitologists in the world at large, limited and conferred only upon exceptional qualifications and prominence in the field of parasitology. Annual dues one peso, collected only when indicated by financial report. Total membership 20.
Meetings: Three or four meetings a year, at the Institute of Hygiene.
Research funds, medals, etc.: Members may apply for grants-in-aid from the National Research Council of the Philippines."

Dr. Turbangui further stated that current information concerning the Society is being requested by the National Research Council of the United States.

3. Having thus briefed the members, Dr. Tubangui opened the table for nomination of new officers.

4. Dr. Lara moved to unanimously elect Dr. Tubangui and Dr. Dy as president and secretary-treasurer, respectively, of the Society. This was carried.

5. The following were unanimously elected members of the Executive Committee:

Dr. Lope M. Yutuc, Dr. Eusebio Y. Garcia, Dr. Antonio Ejercito.

6. The President opened a round-table discussion on current parasitological problems. Topics taken up:

a. *Malaria.*

(1) Need for further studies to re-evaluate known antimalarials available in the P. I.

* (2) Need for studies to determine the definite relapse pattern of Philippine strain or strains of *vivax, falciparum* and *malariae malaria.*

* (3). Possible presence in the P. I. of vector or vectors of malaria other than *A. minimus flavirostris.*

(4) Differentiation between the primary and secondary attacks of malaria during the first 7 days by microscopic examination of the blood smear. Dr. Garcia claimed that in primary infections, gametocytes are never found in the blood smear during the first 7 days, and that their presence indicates a relapse. This provoked a lengthy discussion.

* (5) Dissection of anopheline mosquitoes for sporozoites and oöcysts. Sporozoites found in *A. maculatus* and *A. Mangyanus.*

* (6) Breeding of *A. minimus flavirostris* above 3,000 ft. and in brackish water with a salinity of 1:1,280 total chlorides.

b. *Schistosomiasis*

(1) Provinces in the P. I. where the disease is prevalent.

(2) Distribution of the snail intermediate host in P. I.

(3) Problems presented by livestock in the spread of the disease.

(4) Value of "liver index" and "average enlarged liver" in determining the incidence and intensity of the disease in a community.

(5) Bionomics of the snail intermediate host.

(6) Control measures.

c. *Filariasis.*

(1) Are there many vectors of this disease in the P. I.?

d. *Entomology.*

(1) Need for systematic survey of Philippine insects and arachnids in connection with entomological problems related to human diseases, like Equine encephalomyelitis, rickettsial fevers, etc.

7. One peso was collected from each of those present in the meeting.

8. The meeting adjourned at 6:15 p.m.

FRANCISCO J. DY
Secretary-Treasurer

Approved:
M. TUBANGUI
President

* Am working on these problems now. We are also examining blood for micro-filariae. *W. Bancrofti* is supposed to be the only species here. But there is strong suspicion *Malayi* is also in the P. I. PAGINTO

THE FIRST INTER-AMERICAN SANITARY ENGINEERING CONGRESS WILL MEET IN SANTIAGO, CHILE ON APRIL 8–14, 1948, AT THE UNIVERSITY OF CHILE. A balanced program has been developed, pertinent to the work of the Sanitary Engineer, with special emphasis on water supply problems, sanitation, and insect control programs.

Those planning to attend the Congress should contact the Secretary for hotel reservations, and should also notify him of date of arrival, plane flight, train numbers, etc. Manufacturers exhibiting at the Congress are requested to send their equipment and other materials directly to the Secretary, whose address is as follows:

Ing. Ruperto Casanueva del Canto
Secretario del Primer Congreso Interamericano de Obras de Salubridad
Tenderini 127
Santiago, Chile

EDITORIAL SECTION

IT IS NOW TIME TO TAKE STOCK AND TO FORMULATE A WELL THOUGHT OUT "FIVE YEAR PLAN"

By the time we assemble for the annual meetings in March, the American Mosquito Control Association will have successfully completed the first four years of its existence as a national society. During these four years the Association has made a truly remarkable growth; until it is now well established as a national organization, and its official journal, Mosquito News, is widely sought by contributors as a desirable medium for the publication of scientific and technical articles appropriate to its special field.

The Association has had its share of growing pains, not the least of which has been the rapidly mounting cost of printing, and the resulting problem of keeping Mosquito News and the Association itself financially on an even keel.

The increasing cost of printing has fortunately been offset by the increased income from dues paid by a rapidly increasingly membership; but this mounting cost of printing has held back a hoped for increase in the number of pages printed in Mosquito News, so that a larger Mosquito News must await a still further substantial increase in membership or a subsidence in current inflationary trends.

With expansion in geographic scope and in types of interest and activities represented among its membership, has come increasing and more diverse member interest with suggestions for new and wider services and responsibilities that might be assumed by the Association.

Notable among these suggested services and responsibilities are:

1. The preparation and publication by the Association of special bulletins relating to new procedures in mosquito control and related work.

2. The acceptance, organization and administration of industrial research fellowships for the investigation of special problems concerning mosquito control and related work, to be financed by commercial concerns with a profit interest in their solution.

The urgency with which some of these suggestions are advanced, and the opportunities and responsibilities they represent, make it highly desirable at the coming annual meeting that the Association pause to take stock of their implications, and of the organizational and financial adjustments their adoption would require.

MOST IMPORTANT AMONG THESE REQUIRED ADJUSTMENTS WOULD BE INCORPORATION OF THE ASSOCIATION, so that, as a body corporate, it could "sue and be sued, contract and be contracted with," and carry on its business in a business-like manner.

BOTH OF THE TWO SUGGESTED ACTIVITIES CITED ABOVE, namely the publication of special bulletins and the conduct of industrial research investigations, WOULD REQUIRE THAT THE ASSOCIATION HAVE ADEQUATE RESERVE FUNDS, AND both WOULD REQUIRE A MORE FORMAL AND MORE CLOSELY KNIT ORGANIZATION THAN THE ASSOCIATION NOW HAS.

An analysis of the implications of, and requirements for engaging in the two suggested activities is especially in order at this time:

1. THE PUBLICATION OF SPECIAL BULLETINS

would require one of two things:

a. That the Association be prepared financially to allot from $1500 to $2000 or more, for the publication of each such bulletin, and to wait for repayment until such amounts are returned from sales.

b. That funds fully sufficient to cover

the cost of printing any such bulletin ($1500 or $2000) be provided in advance, either in a lump sum from a commercial sponsor, or through the sale of advertising space, or otherwise, WITHOUT SUCH PUBLICATION BECOMING IN ANY MANNER WHATEVER, A CHARGE AGAINST THE RESOURCES OF THE ASSOCIATION.

Printing costs must be paid at once; returns from bulletin sales are likely to be slow; and mounting costs of printing MOSQUITO NEWS have left the Association insufficient reserve to permit any adventure into the field of special publications, EXCEPT BY WAY OF THE SECOND ALTERNATIVE.

ANY USE OF ASSOCIATION CREDIT FOR SUCH A PURPOSE AT THIS TIME WOULD BE UNSOUND FINANCIAL POLICY.

2. ASSUMPTION OF RESPONSIBILITY FOR MANAGING LARGE FELLOWSHIP FUNDS

in the administration of industrial research investigations, would require a radical reorganization of the Association which might better assure definite continuity of established policy; continuous experienced administration of its affairs through longer tenure and resulting greater experience for its officers; and, especially, greater provision for training new officer material through geographically more widely respresentative, and numerically larger groups of junior officers, kept actively employed with Association business.

But whether any such suggested activities are adopted or not, a reorganization of the Association along lines more appropriate to the discharge of such responsibilities would be sound policy with reference to the conduct of its present routine affairs.

IN ANY CASE, SUCH REORGANIZATION WILL BE ESPECIALLY NEEDED IF, AS MANY SEEM TO THINK, WE ARE LIKELY SOON TO BE CONFRONTED BY A PERIOD OF FINANCIAL STRINGENCY.

As this editorial is being written, it is hoped that such a reorganization may be effected at the annual meeting of the Association in March.

Present suggestions before the Committee on Constitution and By-Laws would provide, because of its prestige, for incorporation through a Charter granted by Act of Congress; no constitution other than this charter; and government of the Association otherwise, provided through by-laws, the amendment of which should not be too difficult.

The first step would be adoption of an initial set of by-laws patterned to conform with the specified requirements for a charter granted by act of Congress.

The next step would be to authorize the officers of the Association to proceed as promptly as possible with the incorporation proceedings.

REVIEWS AND ABSTRACTS

Residual Spray Applications to Salt-Marsh and Jungle Vegetation for Control of Mosquitos. By A. H. Madden, H. O. Schroeder, and A. W. Lindquist. J. Econ. Ent. 40(1):119–123, 1947. Preliminary tests with residual-type spray applications on open marsh and jungle vegetation for control of adult salt-marsh mosquitoes are reported.

On the salt-marsh vegetation, DDT was applied in three forms; 5 per cent oil solution, 5 per cent xylene-water emulsion, and 5 per cent aqueous suspension, and at rates ranging from 5 to 30 gallons per acre. The effectiveness of the treatments was determined by exposing houseflies and mosquitoes to samples of vegetation collected from the plots, supplemented by observations and trapping records. The results of the tests were somewhat erratic and apparently were influenced by the factor of foliage injury from heavy applications of the solution and the emulsion. There was sufficient evidence, however, to support the conclusion that such treatments offer promising possibilities for mosquito control in salt-marsh areas.

On jungle vegetation, tests were made with DDT in two forms and with pyrethrum and benzene hexachloride. DDT was applied as a 5 per cent oil solution and a 5 per cent aqueous suspension. Pyrethrum was applied as a solution of 1 per cent pyrethrins and 5 per cent piperonyl cyclo-hexenone in kerosene. Benzene hexachloride was applied as a benzene-water emulsion containing 5 per cent of the crude product of 12 per cent gamma isomer content. All treatments were made at the rate of 5 gallons per acre. Results were determined by landing-rate counts of mosquitoes in the treated areas and confirmed by tests with houseflies on vegetation collected from the field. The DDT suspension was the most effective application. It was concluded, however, that benzene hexachloride at a higher concentration might be equal to or better than the DDT suspension.

A comparison of the results with the DDT treatments in the two vegetation areas reveals that the treatments on the jungle growths were more effective than those on the salt-marsh. This is explained on the basis that the density and physical properties of the marsh vegetation prevents so thorough a treatment as is possible in the jungle.

Further work on a large scale is recommended to properly evaluate this method of mosquito control as to effectiveness and cost.—R. E. Heal, Merck and Co., Rahway, N. J.

A Study of Mosquito Behavior. An Experimental Laboratory Study of the Mating Behavior of *Aedes aegypti* (Linnaeus). By Louis M. Roth. (in press, American Midland Naturalist, January (?) 1948).

Experimental evidence is presented to confirm Johnston's and Mayer's hypothesis that in Culicidae Johnson's organ is aural in function, an assumption previously based chiefly on morphological evidence. Experiments also proved that the males perceive vibratory stimuli as had been hypothesized in the literature.

The sound produced by the female of *A. aegypti* in flight is the external stimulus which attracts and induces the male to copulate. Odor and sounds other than those made by the female in flight play no rôle in the mating behavior. The male attempts to copulate when a sufficient number of antennal fibrillae are extended making possible the perception of the sound of the flying female. This occurs about 15 to 24 hours after emergence and by this time the hypopygium has rotated sufficiently so that copulation can be successfully completed. Copulation occurs only when the female begins to fly voluntarily at least several hours after emergence. By this time she becomes "attractive" because the sound she makes in flight falls within the range which will stimulate the male. Very young females are "unattractive" since the sound produced by them in flight falls outside of the range which will attract the male. Sexually active males cannot differentiate between recently emerged males and old females since the sounds made by very young males in flight fall within the spectrum which will induce older males to copulate. The male responds to a range of sound frequencies rather than to a single fixed frequency; thus *aegypti* males attempt to copulate with males and females of several different species of Culicidae because the sounds made by these mosquitoes fall within a stimulating range.

The instinctive mating behavior of *aegypti* males whether elicited by a female mosquito or by mechanically produced sounds is basically the same. These coordinated reflex actions, depending upon the source of the stimulus, may be tabulated as follows:

Source of Stimulus	*Behavior of Male*
A. Female in flight	1. Flight 2. Attraction 3. Seizure of female 4. Clasping female's genitalia
B. Tuning fork (e.g. 480vps.)	1. Flight 2. Attraction 3. Seizing response 4. Clasping response

The seizing response elicited by the sounds of the tuning forks or an audio oscillator speaker consists of clinging with the front and middle legs to the cloth of the cage, and vibrating the wings rapidly. The clasping response usually follows the seizing response and consists of flexing the abdomen ventrad.

The upper and lower limits of sound frequencies which will induce a mating response from *aegypti* males are about 100 and 800 cycles per second. The limits vary with the age and virginity or non-virginity of the males. With increase in age both virgin and non-virgin males respond to a wider range of sound but the range of non-virgins which have copulated repeatedly is narrower than that of virgin males kept isolated from females. The practical application of the response of mosquitoes to sound is discussed and it is concluded, that, at present, it appears unlikely that a killing device employing sound as an attractant would be a more efficient or economical substitute than the present methods of mosquito control.

The front and middle tarsi of the male are structurally suited for seizing and holding the female. The hind tarsi take little part in mating. The female tarsi are not suited for seizing and she does not cling to the male or hold him to her during copulation. Knab's hypothesis that the positions assumed by mosquitoes during copulation are correlated with the female tarsal claws is unfounded and apparently was based on the erroneous field observation that the female clings to the male. The hypothesis is suggested that the face to face and end to end positions assumed by different species of mosquitoes during copulation might be correlated with the degree of development of the last tarsal segments and claws of the male's front and middle legs.—LOUIS M. ROTH, Entomology Laboratory, U. S. Army Quartermaster Depot, Philadelphia 45, Pa.

THE MOSQUITOES OF BWAMBA COUNTY, UGANDA; PART V. "VERTICAL DISTRIBUTION AND BITING-CYCLE OF MOSQUITOES IN RAIN-FOREST, WITH FURTHER OBSERVATIONS ON MICROCLIMATE." By A. J. Haddow, J. D. Gillett, and R. B. Highton. Bull. Ent. Res. 37(Pt. 3):301–330. 1947.

Since 1937, field investigations on the epidemiology of yellow fever have been carried on in Bwamba County, a small heavily-forested area in the extreme west of Uganda. Yellow fever virus was isolated in 1941 from one human case and from *Aedes (Stegomyia) simpsoni* Theo. and other *Aedes*, however *A. simpsoni* was not considered the principal vector since it is a sylvan mosquito. It was concluded that an arboreal mosquito was the most likely transmitter because it is known that yellow fever is endemic among the monkeys of the Bwamba forests, especially since a high rate of immunity is shown by certain species that rarely descend to the ground. Although several *Aedes* species show arboreal tendencies it is the belief of the authors that *Aedes africanus* may play a large part in the transmission of yellow fever among monkeys. Evidence in support of this theory is given.

Some 57 mosquito species were collected although many Culicine were not identified. *Anopheles gambiae*, in unusually heavy concentration, was found to be by far the most common mosquito at all levels of elevation, over 93 per cent of all mosquitoes collected being *A. gambiae*.

Information relative to the occurrence of mosquitoes at different elevations and contrasting forest cover is discussed at some length. Biting habits at these levels and at different times of day and season are given.

It was interesting to note that certain species were collected principally at heights over 50 feet while other species were in the lower stratum.

A discussion of investigational methods at the various forest levels, description of the forest areas chosen and an interesting description of the forest microclimate encountered is given.—G. EDWIN WASHBURN, Turlock Mosquito Abatement District, Turlock, Calif.

A MALARIA RECONNAISSANCE OF THE REPUBLIC OF HAITI. By J. H. Paul and Athemas Bellerive. Jour. Nat. Mal. Soc. 6(1):41–67. 1947.

1. A total of 31,285 spleen palpations were made in 826 schools of Haiti. Splenic enlargement was noted in 18.4 per cent of the children.

2. The most malarious areas are the arrondissements of Aquin, Hinche, Mirebalais, Trou, Nippes, Tiburon, Coteaux, Fort Liberté, Leogane, and Cayes—all with spleen rates higher than 30 per cent. The few areas of Haiti that are malaria free, are the higher mountain valleys and the southwest slopes where the rainfall is very low.

3. Blood smears were made on 11,841 children, and the parasite rate, adjusted to all those given spleen examinations, was 31 per cent.

4. The most common type of parasite was found to be *P. falciparum*, which was responsible for 86.6 per cent of the total infections; *P. malariae* accounted for 8.9 per cent, and *P. vivax* for only 1.9 per cent.

5. Three species of *Anopheles* were found in Haiti. *A. albimanus*, the important local vector, was present in 24 out of 27 arrondissements. *A. grabhami* was also widely distributed, being found in 19 arrondissements. *A. vestitipennis* was discovered in only one locality and is reported for the first time.—Author's summary and conclusions.

SOME RECORDS OF MOSQUITO DISSECTIONS IN NORTHERN NEW GUINEA. By J. P. Toffaleti and Willard V. King. Jour. Nat. Mal. Soc. 6(1): 32–36. 1947.

Sporozoites of malaria parasites were found in the salivary glands of two specimens of the "intermediate" form of the *punctulatus* series of *Anopheles*, among 138 gland dissections of specimens of this form collected in native villages in the Hol-

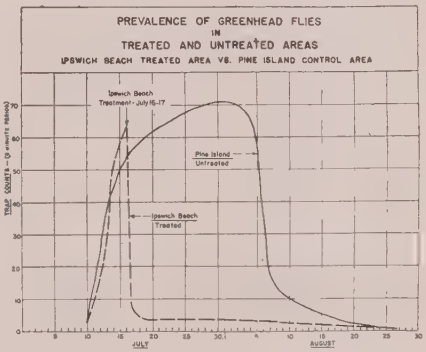
landia area of northern New Guinea. This is the first record so far as known of infection in this form, which was the predominating one in these villages. Gland examinations of 12 specimens of subspecies *punctulatus* and 36 *farauti* (formerly known as *moluccensis*) were negative. No infections were found in a series of 119 *A. karwari* obtained from a military camp located several miles from any native village.

Filaria infections were found in the thoracic muscles or head of 20 of 203 specimens of the *punctulatus* series, for an infection rate of about 10 per cent. Seven of the specimens (representing each of the three forms) contained matured larvae. Six individuals among 268 *Armigeres obturbans* and one among 13 *Aedes (Aedes)* sp. contained immature filariae in the thoracic muscles. Small numbers of nine other culicine species were negative.—Authors' summary.

CONTROL OF THE GREENHEAD FLY (*Tabanus nigrovittatus*) IN MASSACHUSETTS. By Bertram I. Gerry and Norman S. Bailey (Massachusetts Public Health Department and State Reclamation Board). Legislative Report S–429, 1948.

Brief studies of the life history and habits of the Greenhead Fly were conducted as a preliminary to the control program. Although the larvae were found scattered generally over the salt marsh, the greatest density occurred in areas where the sod contained about 70 per cent moisture, a 6 per cent chloride content, and supported a dense ground cover. The adults began to emerge about the first of July and continued over a period of approximately four weeks. The flies migrated inland from the marsh for a distance of one mile but returned to rest on the marsh grass overnight or during periods unfavorable for flight. For all practical purposes, it may be assumed that the Greenheads produce one generation per year. It was found that control methods, directed at the fly stage, were the most effective.

Recreational centers and summer colonies were relieved of the Greenhead nuisance by establishing treated barrier zones on the marsh land adjacent to the areas to be protected. Spraying operations were conducted with various types of equipment but airplane spraying proved to be the most effective and most economical. The dosage was scheduled with a maximum limit of 2 lbs. of DDT per acre because of information gained from DDT tolerance experiments conducted by the U. S. Fish and Wildlife Service in 1945 and 1946. Aluminum stearate, at the rate of 1 per cent by weight, was added to the Xylene-oil-DDT spray to determine its efficacy in prolonging the residual effect. Data acquired from cage tests showed that spray made up in the proportions as follows: Xylene, 1 qt.; DDT, 1 lb.; No. 2 Fuel oil, 3 qts.; and aluminum stearate, 1 per cent by weight, and applied at the rate of 1.6 lbs. of DDT per acre, provided a 12 day residual. Spray in the same proportions, but lacking the aluminum stearate and applied at the rate of 1.77 lbs. of DDT per acre, was less potent and lost its residual effect in less than 12 days. The operational costs indicated that effective Greenhead Fly control may be accomplished with DDT, applied by airplane, at not more than $2.50 per acre.—B. I. GERRY



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